MATE HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES

30th Workshop on Energy and Environment

December 12-13, 2024, Gödöllő, Hungary

Book of Abstracts

Editors: István Farkas
Piroska Víg

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Editors

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CONTENT

PREFACE

Successful events in the series of the Seminar/Workshop on Energy and Environment (EE) were organised yearly since 1995 under the auspices of the Department of Physics and Process Control, Institute for Environmental Engineering Systems, Szent István University Gödöllő, Hungary (recently Department of Physics, Institute of Mathematics and Basic Science and Department Mechatronics, Institute of Technology, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary), including active participation also from foreign institutions working in the field of the application possibilities of renewable energy resources.

The aim of the Workshop to provide a forum for the presentation of new results in research, development and applications in connection with the issues of energy and environment.

This is now a call to take part in the abovementioned event along with to submit two-page abstract of potential contributing papers falling into the Workshop topic. The Abstract Volume of the Workshop will be published and distributed among the participants during the event. The language of the Workshop is English, no simultaneous translation will be provided.

The deadline of the two pages abstract submission: November 24, 2024

Further information, please, contact:

Prof. I. Farkas
Founding Chairman of the Workshop

Institute of Technology
Hungarian University of Agriculture and Life Science
Páter K. u. 1., H-2100 Gödöllő, Hungary

E-mail: Farkas.Istvan@uni-mate.hu
Tel: +36 28 522055
https://mathematics.uni-mate.hu/ee2024

A WASTE TO ENERGY: PERSPECTIVE AND PROSPECTIVE

A.S. Ardi[1], D. Rusirawan[1], I. Farkas[2]

[1]Department of Mechanical Engineering, Institut Teknologi Nasional Bandung
Jl. PKHH. Mustapa No. 23 Bandung 40124, West Java, Indonesia
[2]Institute of Technology, Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: aldoardi03@gmail.com

Energy needs will increase as the global population grows, and this situation will be followed by increasing carbon emissions. Currently, the world still primarily depends on fossil fuels, especially liquid fuels, and coal, as energy sources. However, their use leads to pollution and emissions, causing extreme weather and climate change. Under global agreements to reduce fuel emissions, countries must explore low-to-zero carbon energy sources. In Indonesia itself, bioenergy holds significant potential to support the 2050 energy mix (Simanjuntak, 2023).

In 2022, Indonesia produced 21.1 million tons of waste that came from 202 cities, in other words around 58 tons waste is produced every day. However, only about 65.71% (13.9 million tons) of this waste managed properly through landfills, recycling, or waste-to-energy system, leaving a significant portion unprocessed. Accumulated waste leads to severe environmental impacts, such as soil and water pollution, flooding caused by clogged drainage systems, and increased greenhouse gas emissions from decomposing organic waste. Even more than that, unmanaged wastage poses health risk to communities, including the spread of diseases and reduced air quality. Addressing this issue requires improving waste management infrastructure and public awareness (KEMENKO PNK, 2023).

One step to overcome the wastage problem is to use waste as a resource for generating electricity. The waste power plant in Bekasi, Indonesia generates electricity around 750 kW for 100 tons of waste every day. This idea means there is potential electricity production of 54,000 MW, not to mention the accumulation of waste from the previous year. Fig. 1. Shows the total number of the waste produced in Indonesia from 2019 to 2023.

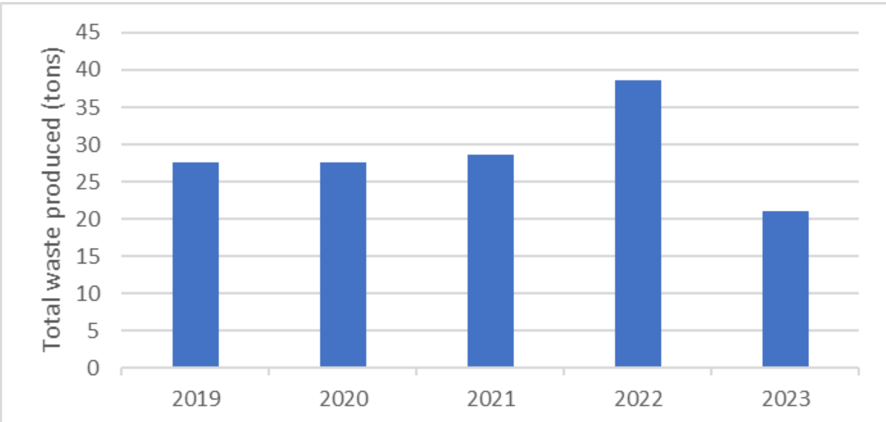

Fig. 1. Total amount of waste produced from 2019 to 2023 (SIPSN, 2023)

Expanding the use of waste to generate electricity could significantly reduce unmanaged wastage while addressing the needs of energy. By converting organic and non-recyclable waste into electricity, not only decrease the environmental hazard posed by waste but also diversify its energy mix with a sustainable source.

Technically, to convert waste to electricity are rely on processes like incineration to recover energy from waste. Incineration, the most commonly applied method, involves burning waste at high temperature to produce steam for electricity generation. Advanced system equipped with air pollution control can significantly reduce emissions of harmful pollutants.

As a perspective ahead, waste as energy source has the potential to play significant role in addressing both waste management and energy generation challenges. As urban populations grow and waste production increase, this system is prospective and could provide a sustainable solution by converting large quantities of waste into electricity.

Acknowledgments

This research synopsis is released as an outcome of a multidisciplinary international partnership between ITENAS Bandung, Indonesia, and MATE Gödöllő, Hungary.

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IMPACT OF INPUT PARAMETERS ON ANN POWER PREDICTION PERFORMANCE FOR PHOTOVOLTAIC SYSTEMS

A. Altaye[1], P. Víg[2], I. Farkas[3]

[1]Doctoral School of Mechanical Engineering, [2]Institute of Mathematics and Basic Science, [3]Institute of Technology
Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: Altaye.Aschenaki.Tadesse@phd.uni-mate.hu

Photovoltaic technology converts solar radiation into electricity efficiently and sustainably (Moro et al., 2024). These panels offer eco-friendly, low-maintenance energy solutions with applications ranging from power generation to IoT devices. Despite efficiency levels between 8% and 20%, the performance of photovoltaic systems depends on factors like irradiance, temperature, electrical load, and panel age. By considering inputs such as temperature and solar irradiance, current-voltage (I-V) characteristics can be generated to assess performance metrics like maximum power point and fill factor.

Artificial Neural Networks (ANNs) is a machine learning technique shaped by various scholars (Asghar et al., 2024). Researchers have utilised ANNs to predict panel output power in solar PV generation effectively (Saraswathi et al., 2022).

Fig. 1 illustrates the ANN model used in this analysis. The model comprises four input nodes, one hidden layer with 10 neural networks, and a single output layer.

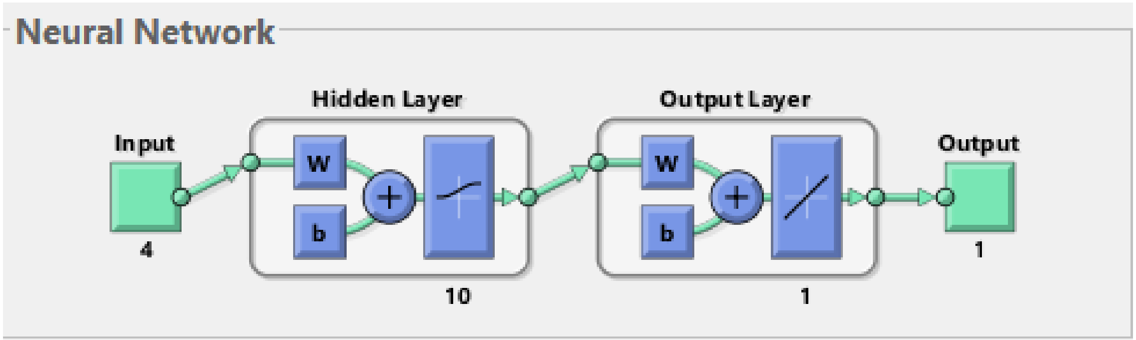

Fig. 1. Neural network diagram

Fig. 2 and 3, depict the power prediction performance of the ANN with different numbers of input parameters in comparison to measured values. When radiation and temperature are included as input parameters, the ANN's performance declines, indicating that these factors do not have a direct impact on power generation within the PV system. This finding suggests that relying solely on temperature and radiation may not yield an accurate representation of actual power output.

Various input parameters were examined to assess the ANN's power prediction performance for the PV system. The results indicate that using temperature, radiation, voltage, and current as input parameters yields minimal error compared to scenarios where only radiation and temperature are used or when only voltage is considered. Consequently, it can be concluded that as the number of input parameters increases, the power prediction performance improves proportionally.

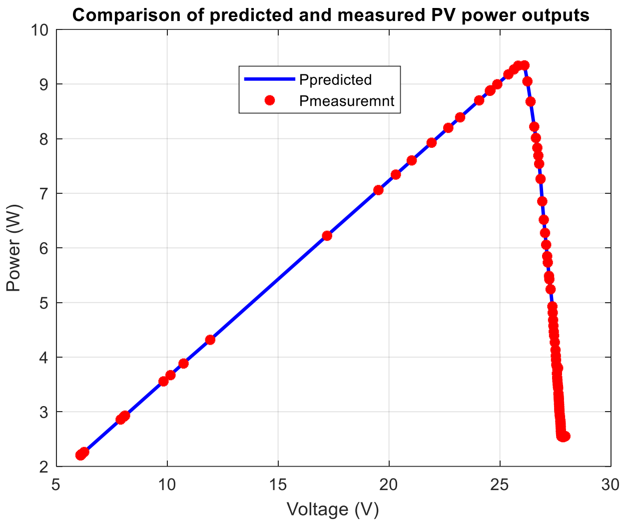

Fig. 2. P-V curves of temperature, irradiation, voltage and current inputs

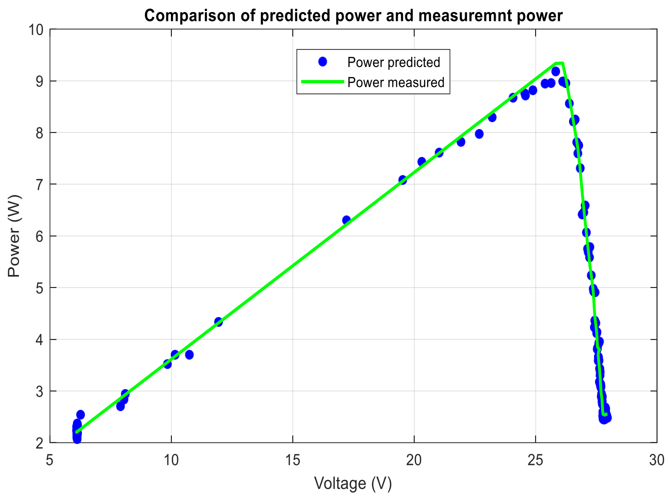

Fig. 3. P-V curves of temperature and irradiation inputs

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THE SIGNIFICANCE OF ASSESSING THE PERFORMANCE OF SEMI-TRANSPARENT PHOTOVOLTAICS IN AGRICULTURE

N.D. Anggraeni[1,4], I. Seres[2], and I. Farkas[3]

[1]Doctoral School of Mechanical Engineering, [2]Institute of Mathematics and Basic Science,
[3]Institute of Technology
Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
[4]Department of Mechanical Engineering, Institut Teknologi Nasional Bandung,
Jl. PH. H. Mustofa No 23 Kota Bandung, 40124, Jawa Barat, Indonesia
E-mail: Anggraeni.Nuha.Desi@phd.uni-mate.hu

Implementing semi-transparent photovoltaic (STPV) systems in agricultural settings, sometimes called agrivoltaics, represents a potentially fruitful strategy for enhancing the efficiency of land utilisation and satisfying the requirements of the global energy market. Since these systems allow for the transmission of partial sunlight, they make it possible to generate electricity and produce agricultural goods simultaneously.

STPVs are assessed for their energy generation potential and light interaction properties. Energetic performance assesses the efficacy of transforming sunlight into electrical energy (Anggraeni et al., 2024), whereas optical performance examines the STPV's engagement with light. Essential metrics encompass power conversion efficiency, energy yield, fill factor, and spectral response. Integrated analysis enables researchers to optimise STPVs for particular applications, ensuring a balance between energy generation and additional functional requirements such as agriculture or urban integration.

This study aims to evaluate the effectiveness of STPV systems in agricultural settings, focusing on energy production, spectral transmission characteristics, and crop growth and yield, aiming to improve sustainable agrivoltaic systems.

The spectrum data of light transmitted through STPV panels offers essential insights into their spectral transmission characteristics, especially within the photosynthetically active radiation (PAR) range (López et al., 2023). As illustrated in Fig. 1, the solar spectrum intensity highlights the spectral transmission characteristics crucial for PAR.

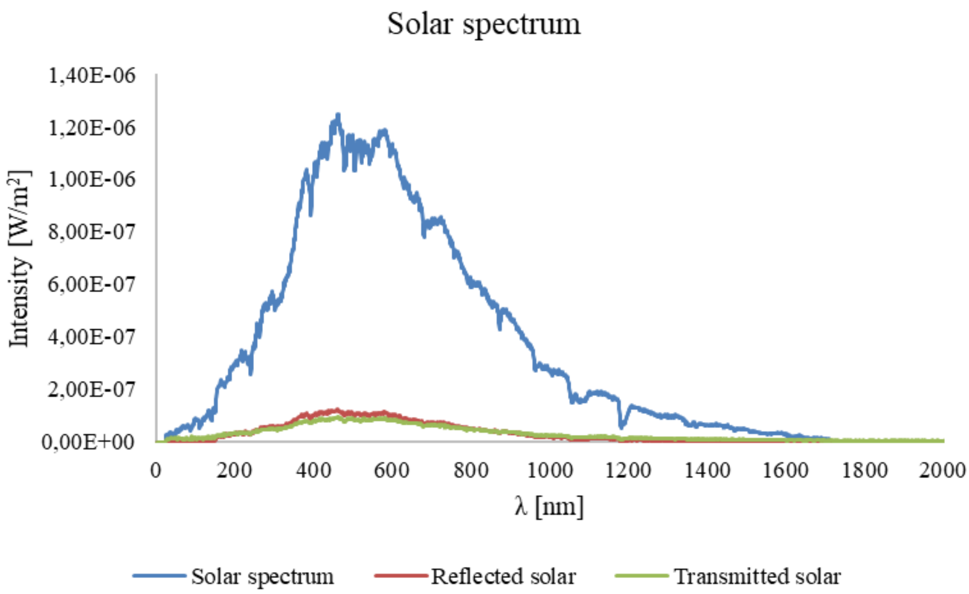

Fig. 1. Solar spectrum intensity

The analysis of this data demonstrates the impact of specific wavelengths on crop growth and yield, thereby ensuring alignment between energy production and agricultural productivity. Measuring energy yield, spectral properties, and environmental effects – including temperature control and water-use efficiency – facilitates customised solutions harmonising food and energy production (Baxevanou et al., 2020). A comparative analysis of solar intensity, illustrated in Fig. 2, highlights the efficacy of spectral light data in validating agricultural practices.

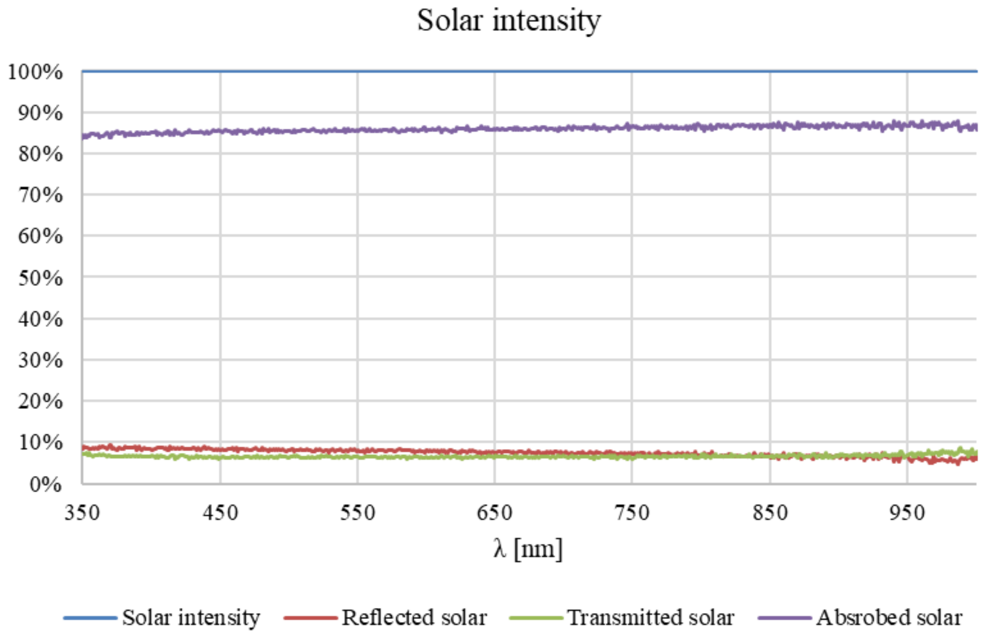

Fig. 2. Comparison of solar intensity

In summary, spectral light data validates the effectiveness of agricultural practices, whereas energy performance evaluates the system's effectiveness in terms of energy production. For STPV systems to be successful in agrivoltaics, simultaneous optimisation is required because of their interdependence.

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RELIABILITY AND MAINTENANCE OF GAS TURBINE VALVES: A REVIEW

Z.M. Azkiya[1], A. Taufik[2], and D. Rusirawan[3]

[1]Undergraduate student of Mechanical Engineering, Institut Teknologi Nasional Bandung, Indonesia
[2] PT Performa Integritas Indonesia (Fortasindo), Bandung, Indonesia
[3]Departement of Mechanical Engineering, Institut Teknologi Nasional Bandung, Indonesia
JL. PKHH Mustapa No. 23 Bandung 40124, Indonesia
E-mail: zaky.muhamad@mhs.itenas.ac.id

Gas turbines are widely used in Indonesia as one of the power plants to generate electricity. During its operation, the performance tends to decrease, especially if related to the reliability term. The causes of the performance decrease are aging and unproperly maintenance, especially to the maintainable items of the gas turbine.

In this works, reliability evaluation of gas turbine, especially for the valve components will be explored, based on maintenance data history. Outcome from this work, reliability of gas turbine system or reliability of sub system (such a valve, etc.) of gas turbine can be determined, and maintenance plan to increase the life time of the system or sub-system of gas turbine can be proposed. The sample of gas turbine for the industrial type can be seen in Fig. 1.

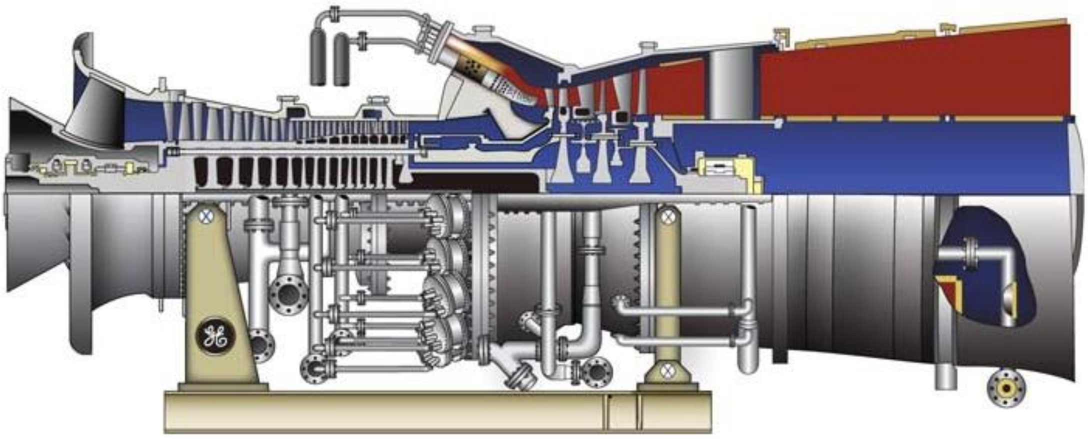

Fig. 1. Industrial-type gas turbine

A valve reliability and maintenance on gas turbines is focussed to be studied. The valves on gas turbines are critical components that serve to control the flow of working fluids, such as air, fuel, and hot gases in the turbine system. These valves ensure that the gas turbine operation runs efficiently, safely, and according to load requirements. The types of valves used in gas turbines include fuel control valves, intake air valves, bypass valves, and pressure relief valves, each with a specific role in regulating operational parameters such as pressure, temperature, and fluid flow.

The reliability of the gas turbine valve plays a crucial role in the maintain performance of the gas turbine system. If the remaining life of the valve can be determined, the proper maintenance can be proposed and scheduled, furthermore the gas turbine operation can be kept reliably, and extend the life of the gas turbine.

Acknowledgments

The synopsis of this scientific work is released as an outcome of the partnership between ITENAS Bandung, Indonesia, and PT Performa Integritas Indonesia (Fortasindo), Indonesia, an engineering consulting company specializing in risk and integrity management.

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ECOLOGICAL STATE OF THE ARTE STUDY OF THE WATER QUALITY OF "ROMANIAN LAKE PADURENI-BESENYŐI TÓ" – EUTROPHICATION ASPECTS

S. Bartha[1,2] and N. Antal[1]

[1]UBB-Cluj – Napoca - Faculty of Environmental Science and Engineering, University Babeș-Bolyai Cluj – Napoca, Extension Sf. Gheorghe, Romania
[2]BIO-C ECOIPAR LTD, 10-Castanilor Street, Ro-520004, Sf. Gheorghe, Romania. Tel: +40722250725, E-mail: sbarthacv@yahoo.ro

The influence of climate change is evident in European lakes, particularly in the alteration of their ecological properties. One significant natural process observed in many lakes in recent years is eutrophication—that process is caused by the nutrient enrichment in water sources that leads to excessive primary biomass production in aquatic ecosystems. This is manifested through algal blooms, reduced oxygen levels, and ultimately, the disruption of lake ecosystems that have evolved over centuries.

This study aims to present results focusing on the physical and chemical characteristics of the water quality of "Pădureni Lake" in Covasna County. As one of the largest artificial reservoir lakes in Covasna, it was constructed in the 1980s by damming the Besenyő stream, which originates in the Bodoc Mountains. Covering an area of 86 hectares, the lake was originally intended for irrigation but has recently become a recreational and fishing hub. The primary water sources are the Besenyő stream and precipitation (rain and snow) within its catchment basin. The lake is not directly affected by sewage from surrounding settlements and guesthouses, as these are managed through individual septic tanks and transported to a regional wastewater treatment unit.

As is known, European Union and national rules and guidelines define the classification of surface water quality, including lakes, based on the class boundaries of physical and chemical elements and ecological parameter data. The work start with the geographically presentation of the Lake location area with the presentation of the water sampling points which was taken from the inflow areas and the mid-shore part of the lake, paying special attention to characterizing the physical and chemical parameters of the analysed samples. That describe the oxygen regime, the nutrients concentration, and the acidification of the lake. Recent extreme weather conditions in Europe, such as heavy rainfall and flooding, have transported large amounts of organic and inorganic matter into lakes, leading to sediment accumulation and pollution. This has intensified algal growth in many lakes.

The sediment accumulation phenomena with the evaluation of the possible quantity of that, in case of the lakes sited in mountains area is important because that indicate the source of inorganic and organic matter at in the inflow points and in another parts where the precipitation supplying the studied lake.

This date indicate the settling volume which can be measured at the point of influence of the stream ore in different established samples taken and measurement points. That was evaluated by using one sedimentation cone stand „ Imhof". This technique, widely used in wastewater treatment, was adapted here to quantify settling sediment volumes effectively.

That parameter was evaluated in the influence point of the Besenyő stream and in two sampling point located in middle coastal zone of the lake. The measured values of the sediment volume was in the influence point 3-4 ml/ L and in case of the middle coastal zone was less than 1 ml/ L. The lake acts as a large sedimentation tank, with transported materials settling at the bottom – a process accelerated by aquatic vegetation, the ecological status of the lake was evaluated following the European Water Directive (EC Directive 60-2000) and the corresponding national laws. These frameworks assess ecological status based on physical, chemical, biological, and hydro-morphological elements, classifying water bodies into five categories: high, good, moderate, poor, and bad (Rizik, et al., 2021).

Base this norm it was selected the principal chemical indicators used for the water source quality classification. The key physical parameters it was studied by measuring and evaluation of the: Electric conductivity (E_c, [µ S/cm]), Turbidity (NTU unit), Total Dissolved Solid (TDS, [mg/l]), pH (acidity), Dissolved oxygen (DO, [mg/l]). The studied key chemical parameter was from the category of principal nutrients, likes nitrogen and phosphorus concentrations; NO_3^- (mg L^{-1}), NO_2^- (mg L^{-1}), PO_4^{-3} (mg L^{-1}). Total P, (mg L^{-1}), also the total Fe $^{+3}$ (mg L^{-1}) is evaluated. Another key indicator is the COD- Chemical Oxygen Demand, that parameter is critical for determining the amount of waste (contamination level) in the water. That is defined as the amount of oxygen equivalents consumed in chemical oxidation of organic matter by strong oxidant like potassium dichromate ($K_2Cr_2O_7$). This parameter was evaluate by one Multiparameter Photometer HI 83314- the samples was treated by the mentioned protocol and standard at 150 °C with helpful of “HI839800 Reactor”.

In all evaluation process it was used methods and procedures/ standard accepted in European rolls and legislation. This work was carried in “Lake Padureni” and the water samples were taken in 3 point in period 2023 summer 2024 spring.

The obtained results generally respects the established values in European water Directive, is it in range to corresponding the moderate and good category. The obtained COD value is corresponding to the class III and the phosphate concentration where to class V. - to bad category. That indicate that the lake can be polluted by different anthropogenic pollution and needed to be discover the pollution source, because the presence of the nutrients and organic matter can be accelerate the algal blooms exacerbating the eutrophication of the lake.

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EFFICIENT ADDED VALUE PRODUCT EXTRACTION AND XYLITOL PRODUCTION FROM ENERGY WILLOW – A SUSTAINABLE BIOREFINERY APPROACH

S. Bartha[1,2], F. Carvalheiro[3], L.C. Duarte[3], N. Antal[1]

[1,2]UBB- Cluj – Napoca -Faculty of Environmental Science and Engineering, University Babeș-Bolyai Cluj –Napoca, Extension Sf. Gheorghe, Romania
[2]BIO-C ECOIPAR LTD, 10-Castanilor Street, Ro- 520004, Sf. Gheorghe, Romania
E-mail: sbarthacv@yahoo.ro
[3]LNEG – Laboratório Nacional de Energia e Geologia, Unidade de Bioenergia e Biorrefinarias, Estrada do Paço de Lumiar, 22, 1649-038 Lisboa, Portugal
E-mail: luis.duarte@lneg

Woody biomass has been globally recognized as a renewable feedstock with the potential to replace non-renewable fossil fuels, reduce global greenhouse gas emissions, enhance local and regional energy security, and create new economic opportunities for rural communities. Short-rotation crops like energy willow are increasingly attractive as a source of wood biomass, reducing forest harvesting and providing a sustainable solution for bioenergy production.

Short-rotation willow is cultivated as a biomass energy crop in Europe and North America due to its desirable traits: rapid growth, high biomass yield, adaptability to diverse climates, and a rotation period of 3-4 years over 20-25 years. Eastern Europe's climatic conditions are ideal for developing energy willow plantations on marginal lands unsuitable for food or feed production. Currently cultivated primarily for bioenergy, new industrial-scale technologies are being developed to extract bioactive compounds like *salicin* – a natural β-D-glucoside of salicyl – from this bioresource (Baker et al., 2022).

Energy willow is classified as lignocellulosic biomass, with high cellulose (36-65%), lignin (17-29%), and hemicellulose (21–28%) content. These components form a complex biomass matrix, which can be deconstructed using various pre-treatment methods. In our study, mild sulfuric acid treatment was applied, yielding fermentable sugars that were converted to bioethanol via classical fermentation technology. Energy willow (*Salix vimialis* var. *Inger*), recognized for its high polysaccharide content (up to 60% on a dry basis), and was subjected to acid hydrolysis. The resulting liquid phase was analysed via HPLC, and the composition informed the selection of optimal biorefinery technologies for xylitol production, which depends on the xylose content of the hydrolysate.

Common feedstocks for microbial xylitol production from acid hydrolysis-derived xylose substrates include corn cobs, sugarcane bagasse, oat husks, and soybean husks (Espinoza-Acosta, 2020). Industrial xylitol production currently relies on the chemical conversion of xylose from xylan-rich hemicellulose hydrolysates obtained from wood and agricultural residues. This process requires harsh conditions (80-140 °C, 31-40 atm), a metal catalyst (e.g., Ni, Ru, Rh), 3-5 hours of reaction time, and multiple purification steps to achieve high-quality xylitol, resulting in moderate yields (50-60%). Biotechnological methods are under investigation, using microorganisms such as yeasts (*Candida*, *Debaryomyces hansenii*, *Pichia guilliermondii*), bacteria, and fungi. Notably, *Debaryomyces hansenii* has been extensively studied for this purpose (Carvalheiro et al., 2007).

Our work was focused to study the possibility of the extraction added value compounds and producing xylitol from the resulted hydrolysate by acid hydrolysis of the energy willow. The added value compound like salicylic acid derivate was extracted from the willow bark by ultrasound treatment. To that it was necessary to evaluate the wood bark ratio. In this case it was qualitatively evaluate resulted liquid phase composition. From the presented dates in scientific literature the salicin yields is in range (13.7-144.2 kg/ ha.) In our experiment it was used the following energy willow samples: EW $_B$-Willow bark harvested in February 2023, (2) EW_{CN} willow wood chip from the same harvesting lot. EW- $_{C45}$ willow chips dried in drying oven at 45 °C and (4) EW $_{GC}$ was noted the debarked green willow samples harvested in June 2023. The samples after mechanical treatment were treated with diluted sulfuric acid and the hydrolysate composition was made by HPLC analysis. The table below show the experiment results. The xylitol yield was evaluated theoretically, is it know that in case of biorefinery process the theoretical hydrolysate recovery is 0.7 at 7 solid liquid ratio is. The experiment dates shows that the green willow, has the highest value of xylose – to xylitol bioconversion yield is 6.7 g/ 100 g dry mass energy willow.

Nr.crt.	Type of E-willow/	Glucose	Xylose	Arabinose	Acetic acid	Levulinic acid	HMF	Furfural	Av-Solid Massloss yields,Ys[%]	YXy-OH [g/100g E-willow]
1	EW_B	8.49	10.06	5.47	2.33	0.06	0.20	0.12	31.47	3.1
2	EW_{CN}	1.86	10.06	1.45	3.12	0.03	0.03	0.19	27.92	3.1
3	EW_{C45}	3.62	13.30	2.82	3.94	0.05	0.10	0.26	26.43	4.1
4	EW_{GC}	4.54	21.85	0.79	6.11	0.17	0.17	0.56	27.82	6.7

Acknowledgments

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RELIABILITY AND MAINTENANCE PLAN OF GAS TURBINE BLADE: AN OVERVIEW AND LESSON LEARNED

D.M. Fadillah[1], D. Rusirawan[2], and A. Taufik[3]

[1]Undergraduate student of Mechanical Engineering, Institut Teknologi Nasional Bandung
[2]PT Performa Integritas Indonesia (Fortasindo), Bandung, Indonesia
[3]Departement of Mechanical Engineering, Institut Teknologi Nasional Bandung
JL. PKHH Mustapa No. 23 Bandung 40124, Indonesia.
E-mail: duta.maulidilatifadillah@mhs.itenas.ac.id

Presently, a gas turbine is one of the power plants that are widely used in Indonesia, besides the steam turbines. During its operation period, the performance of a gas turbine will decrease as a consequence of aging or poor/unstrategic maintenance, including the maintenance plan's management.

Gas turbines are machines that function to convert energy from fuel into mechanical energy through gas combustion. One of the components in a gas turbine is the blades, which function to convert heat energy from gas into mechanical energy by capturing high-pressure heat energy generated in the combustion process. This heat energy is then converted into mechanical energy through blade rotation, which is ultimately used to generate electrical energy (Boyce, 2012).

Failure in a gas turbine system, including component parts or sub of the system, will affect the generating of electric energy and therefore will disrupt of electricity supply.

In this paper, the concept of reliability evaluation of a gas turbine, especially for blade, will be elaborated, initially by knowing the gas turbine in general, identification of the block functional diagram of the system, an inventory of the list maintainable items of a gas turbine, identification of a reliability block diagram of the gas turbine, collect a sample of maintenance's history of gas turbine, including knowing the common of type of failure and failure mode of a gas turbine. The illustration of the industrial type of the gas turbine, is shown in Fig. 1.

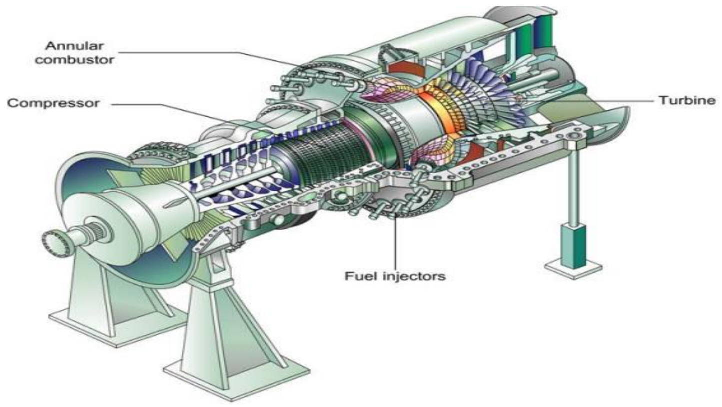

Fig. 1. Industrial-type gas turbine

The reliability of turbine blades is very important, considering that these components work in very extreme operational conditions, such as high temperatures and large pressures (Carter, 2005). This study aims to determine the reliability of gas turbine blades and design an effective maintenance plan to increase an operational life and reduce the risk of failure. Ensuring the reliability of gas turbine blades is essential for gas turbines to work effectively.

The study of blade reliability in gas turbines is carried out using the 2-parameter Weibull distribution method, namely the Shape parameter and the Scale parameter (Taufik, 2024). Shape parameter is a parameter that affects the shape of the slope on the failure rate curve of a device if the value is less than one then the curve will experience a negative slope, if it is greater than one then the curve will experience a positive slope, and if the value is equal to one then there will be no slope. A typical bathtub curve (hypothetical failure rate vs time) can be seen in Fig 2.

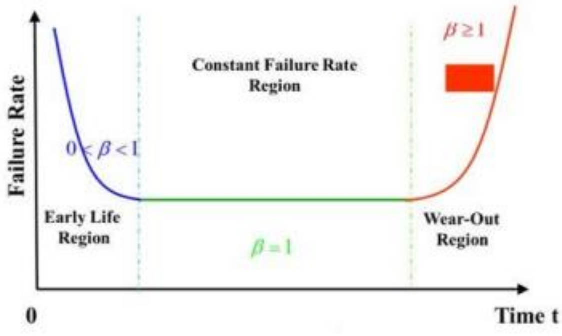

Fig. 2. Effect of Shape parameter on curve

The scale parameter of the Weibull distribution is a parameter that determines how long the data distribution. In simple terms, the larger the value, the longer the expected time before failure occurs (Smith, 2017).

Acknowledgments

The synopsis of this scientific work is released as an outcome of the partnership between ITENAS Bandung, Indonesia, and PT Performa Integritas Indonesia (Fortasindo), Indonesia, an engineering consulting company specializing in risk and integrity management.

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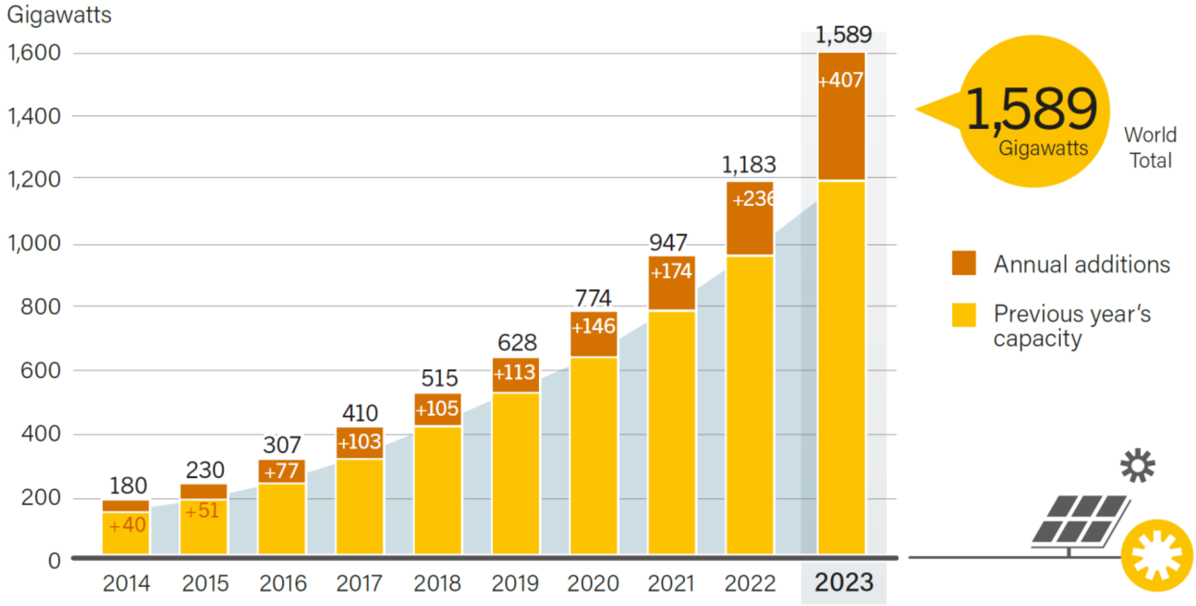
RECENT ADVANCES IN THE FIELD OF PHOTOVOLTAIC TECHNOLOGIES

I. Farkas

Institute of Technology, Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: Farkas.Istvan@uni-mate.hu

This paper is dealing with the recent advances and future scenarios of the very rapidly developing field of solar photovoltaic technologies. The worldwide situation is analysed based on the topics discussed intensively at the Solar World Congress (SWC 2023) organised by the International Solar Energy Society in New Delhi, India and at the EuroSun 2024 Solar Conference organised in Limassol, Cyprus.

In 2023, the solar PV market increased by about 26% reaching the global capacity of 1.589 GW along with the annual additions of 407 GW. The cumulative capacity hit the top growth rate range of the past 10 years. In 2024 the highest new annual capacity was installed in China, and the EU show also a significant increase, with 55.8 GW addition. In Europe the main contributor is still Germany reach 81.6 GW capacity, and followed by Spain and Italy with over 30 GW cumulative capacity and then Spain, Italy, the Netherlands and Poland. Additionally, seome other European countries installed more than 1 GW PV capacity in the year of 2023. Moreover, European Union aiming to deliver over 320 GW of solar photovoltaic capacity by 2025 and almost 600 GW by 2030 (Renewables 2024; IEA PVPS, 2024).

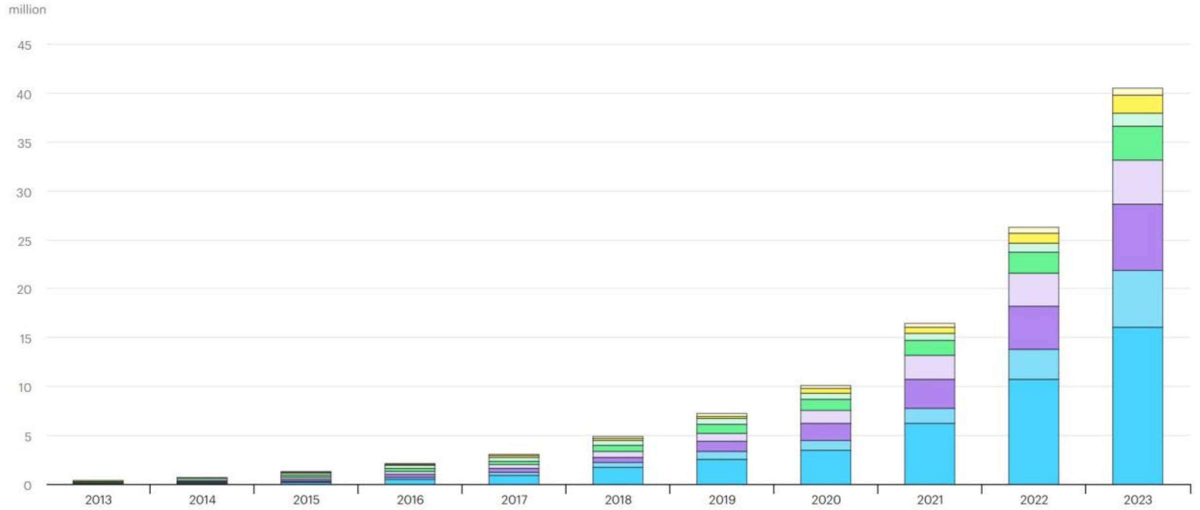


Solar PV capacity (in GW) and annual additions in 2023

In addition to conventional photovoltaic (PV) systems on buildings (rooftop or building-integrated) and ground-mounted systems, an increasing number of PV installations are being deployed on agricultural land (Agrivoltaics), bodies of water (floating PV), and integrated into vehicles (vehicle-integrated PV). These innovative applications of PV technology are expanding the versatility of solar power and offering solutions that can address both energy needs and land use challenges.

For example, in Chile, a 1 MW floating solar PV project was successfully implemented on a water storage reservoir, providing renewable energy to power nearby agricultural activities. Countries like Germany, France, and Japan were early adopters of agrivoltaics, with numerous pilot projects exploring the potential for combining agricultural production with solar energy generation. More recently, nations such as India, the United States, and several others have ramped up efforts to develop large-scale agrivoltaic systems. In the United States alone, over 73 MW of agrivoltaic systems were were on crop production land in 2023, reflecting a growing interest in dual-use farming systems that support both food production and renewable energy generation (Renewables, 2024).

The distribution of global electric vehicles (EV) registrations remains uneven, with key markets leading the charge. The main actors in this market are China (depicted in blue), Europe (purple), the United States (green), and other regions (yellow). The intensity of the colors in the accompanying figure illustrates the market share of battery electric vehicles (light intensity) and plug-in hybrid electric vehicles (higher intensity). Notably, China continues to dominate the EV market, accounting for a significant proportion of global electric vehicle sales. Europe and the United States also show robust growth.



Global electric passenger car stock (in million), 2013-2023

Concerning to the PV module prices, the high production rates, the improved supply chain efficiency, and the rising market competition led to a significant price drop to the €0.06/W_p. Along with that, the PV cell efficiency, in the laboratory, the best performing modules are based on mono-crystalline silicon with 24.9% efficiency, the high concentration multi-junction solar cells achieved an efficiency of 47.6%, and modules with concentrator achieved 38.9% (NREL report, 2024). The record cell efficiency for Perovskite is 33.7% (Fraunhofer ISE, 2024). At module level it is intended to develop higher power ranging at 700 W-plus mainly for building applications.

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THERMAL EFFECTS EVALUATION ON PHOTOVOLTAIC MODULES

G.N. Farros[1], U.A. AlBayumi[2], and D. Rusirawan[3], I. Farkas[4]

[1]Undergraduate student of Mechanical Engineering, Institut Teknologi Nasional Bandung
[2]Indonesia Aircraft Industry (PT. Dirgantara Indonesia), Bandung, Indonesia
[3]Departement of Mechanical Engineering, Institut Teknologi Nasional Bandung
Jl. PKHH. Mustapa No. 23 Bandung 40124, West Java, Indonesia
[4]Institute of Technology, Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: ghazynukhrijaf@gmail.com

The thermal effect of solar power plant (SPP) system is essential to be evaluated as a basic to optimize the performance of the systems. In this study, an evaluation of parameters related to thermal effect of a photovoltaic module will be performed, under various environmental conditions.

Generally, the performance of photovoltaic (PV) module can be influenced by parameters which called as optical, thermal and electrical models. All these parameters is affected by environment & operation condition, and material properties & module design, as shown in Fig. 1 (Mittag et al., 2019).

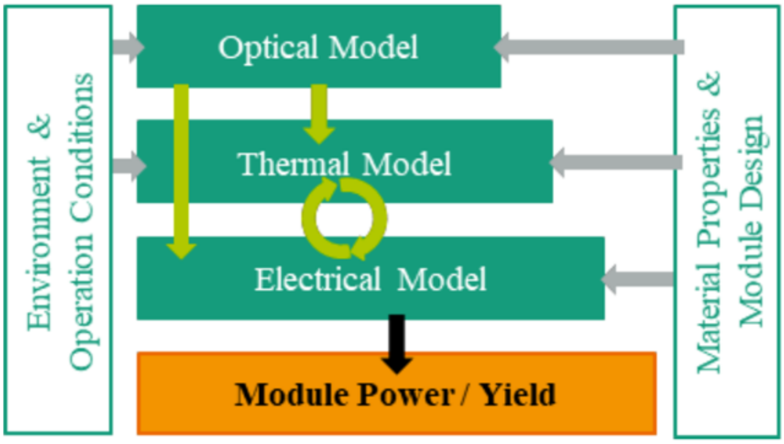

Fig. 1. Factors that influence

The thermal modelling method is used to simulate heat flow and identify factors that affect thermal efficiency, such as material thermal conductivity, heat transfer coefficient, and solar radiation.

In previous research, it was found that there is a decrease in PV module performance in line with increasing temperature. The operating temperature has a crucial role in the PV conversion process. The electrical efficiency and output power of PV module both depend linearly on the operating temperature (Dubey et al, 2013).

This study designs a thermal model that considers the parameters number such as solar radiation intensity, environmental temperature, wind speed, and the material properties of the photovoltaic module. As shown in Fig. 2, and takes into account the thermal effects that occur in photovoltaic (PV) modules. This model is built on the principles of heat transfer, namely conduction, convection, and radiation, to predict the temperature distribution on the surface and internal parts of the photovoltaic module.

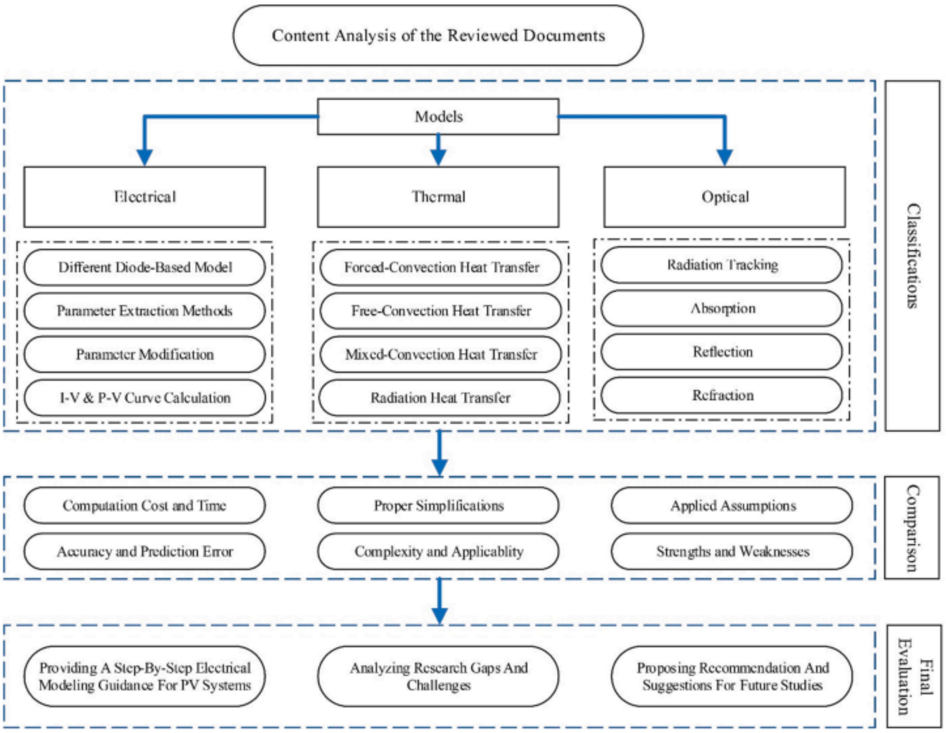

Fig. 2. Parameters of PV modules

To obtain the data required for calculating the thermal effects on the photovoltaic module, some additional characterisation is needed, as:

1. Photovoltaic module temperature
2. Photovoltaic module efficiency based on temperature
3. Convection heat transfer coefficient
4. Dynamic temperature model using differential equations

Acknowledgements

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HEATLESS TECHNOLOGY IN STEEL PAINTING PROCESS: AN OVERVIEW

M.A. Febrianto[1], D. Rusirawan[2]

[1]Graduate Student of Mechanical Engineering, Institut Teknologi Nasional Bandung
[2]Department of Mechanical Engineering, Institut Teknologi Nasional Bandung
JL. PKHH Mustapa No. 23 Bandung 40124, Indonesia
E-mail: mukti.andikafebrianto@gmail.com

Cationic Electro Deposition (CED) Painting is widely applied in the automotive industry as a base layer for coating metal parts. Before any metal or steel part is painted, its surface must be properly prepared to ensure it is free from contaminants that could compromise the adhesion strength of the paint. Surface preparation is fundamental to painting process, use both mechanical and chemical methods. One critical stage in this preparation is degreasing, a process involving the washing of parts through spraying them with an alkaline (base) solution.

In the degreasing process, the selection of chemicals must comply with applicable safety regulations and guidelines. Additionally, environmental impacts must be considered when choosing these chemicals. In practice, external heat is often added to the degreasing process to accelerate chemical reactions. However, this use of additional heat increases costs, energy usage and pollutants. Heat energy is typically generated using boiler, which require fuel and emit combustion pollutants.

An innovative approach has been developed to eliminate the need for heat input (reducing energy consumption) during the surface preparation process. This innovation, heatless technology is by modifying the composition of surfactants (degreasing agent) to break down contaminants without relying on external heat during the degreasing process. By experimenting surfactant composition to find an effective degreasing process can be achieved without additional heat input.

There are two options in the application of this heatless technology, namely by adding the concentration of surfactants currently used that require the addition of external heat. In the test conducted by increasing the concentration of surfactants, it has an impact on increasing foam produced, which affects the degreasing results.

The second option is to add surfactant agents that do not cause excessive foam and has a characteristic as cleaner at room temperature condition. One of the surfactant agents that is added and suitable to this heatless technology is sodium silicate.

The implementation of heatless degreasing enhances energy efficiency in the CED process, particularly for heat exchange systems. Furthermore, this innovation reduces environmental impact by significantly lowering the pollutants released during the process.

Graphical information about an innovation of heatless technology in a degreasing process, types of surfactants, and the effectiveness of oil removal can be seen in Figs. 1-2, and Table 1.

Fig. 1. Different methods

Table 1. Type of surfactants

Before	After
Sodium Metatsticate	Sodium Hidroksida
Sodium Nitrite	Sodium Carbonat, Bicarbonat
	Sodium Silicate

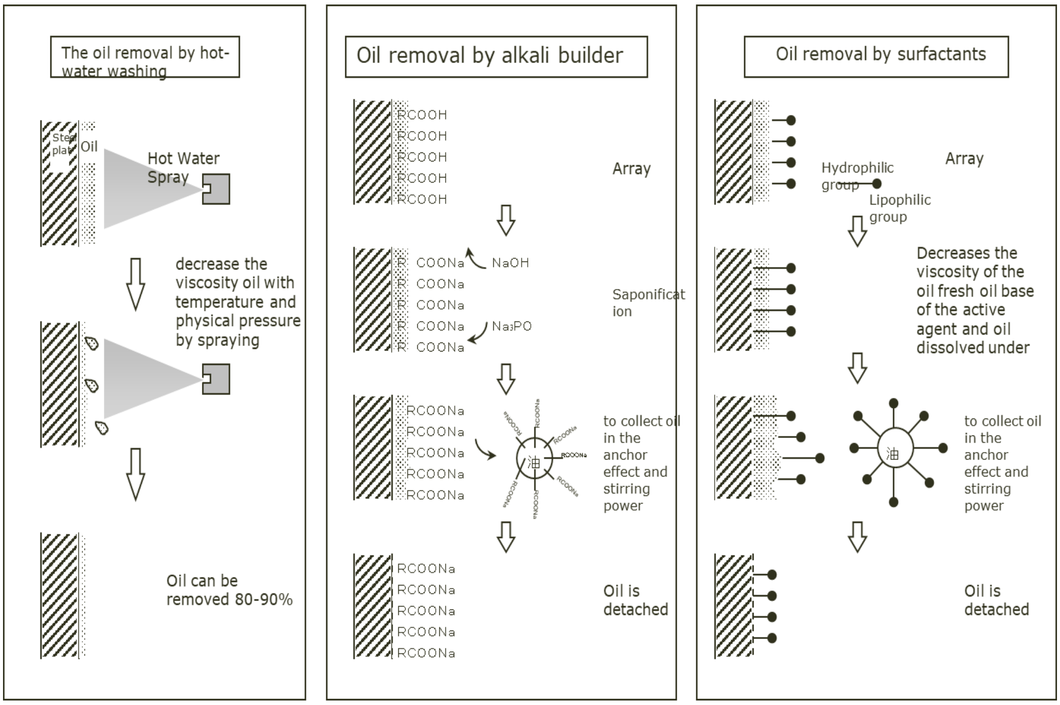

Fig. 2. The effectiveness oil removal

Acknowledgments

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RELIABILITY ANALYSIS OF FRANCIS TURBINES: PRELIMINARY STUDY

Fernando[1], D. Rusirawan[2] and A. Taufik[3]

[1]Undergraduate Student of Mechanical Engineering, Institut Teknologi Nasional Bandung,
[2]Departement of Mechanical Engineering, Institut Teknologi Nasional Bandung
JL. PKHH Mustapa No. 23 Bandung 40124, Indonesia
[3]PT Performa Integritas Indonesia (Fortasindo)
Jl. Venus Barat X no. 5, Bandung 40286, West Java, Indonesia
E-mail: jekfernando02@gmail.com

A water/hydro turbine is a generator's driver in power plants. One of the turbine types is the Francis turbine. Turbine reliability is very important to ensure smooth and safe production and operations. However, the various damages of the water turbines on the power plants will impact the generation and will cause financial losses. Based on general classification, the hydro turbine can be classified as shown in Fig. 1 (Kumar & Singal, 2015).

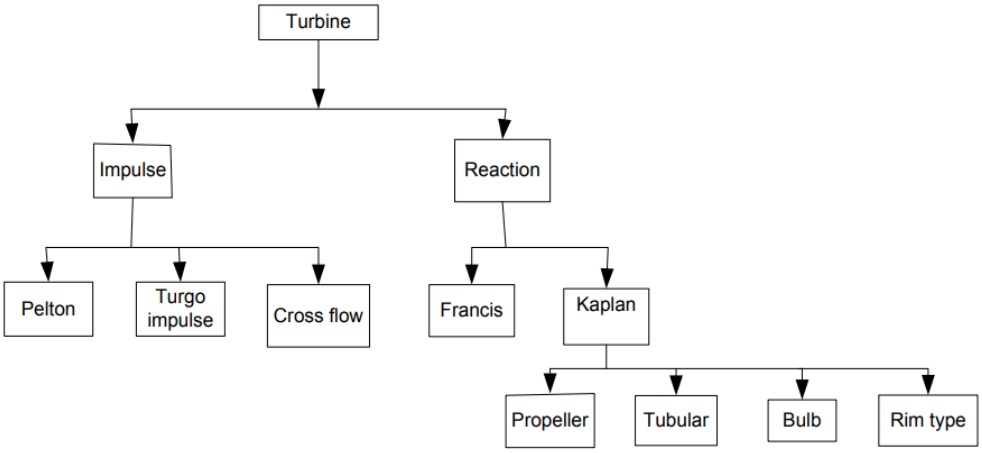

Fig. 1. Hydro turbine classification

It has been found that various failures or problems that occur in impulse and reaction turbines are caused by cavitation, erosion, fatigue, and material defects. Reaction turbines generally fail due to cavitation, while impulse turbines are caused by sludge erosion which leads to a decrease in the performance of water turbines (Kumar & Singal, 2015).

It is necessary to apply Reliability Centered Maintenance (RCM) as a solution that can increase reliability and reduce the risk of damage to the Francis turbine.

In principle, RCM will focus on minimizing the risk of damage by combining several things such as failure analysis, functional analysis, and selection of accurate maintenance strategies. RCM can improve device reliability by preventing or delaying failures, and significantly reducing maintenance costs. RCM is an effective strategy because it can help the industry to achieve goals by increasing reliability and productivity and increasing safety (Taufik, 2024). Each potential failure mode is categorized based on its potential impact on system success or user and equipment safety, so the sets of methods should be implemented to identify the most critical component conditions (Headquarters Department of the Army, 2006).

As a first stage to implement the reliability analysis and RCM on the Francis Turbine, knowing the system, sub-system, sub of sub-system of the Francis Turbines is essential. Information about a block functional diagram of the system, list of maintainable items, and concept of a reliability block diagram should be acquired. The decision logic diagram in general is shown in Fig. 2, and it can be implemented as well in Francis Turbine case.

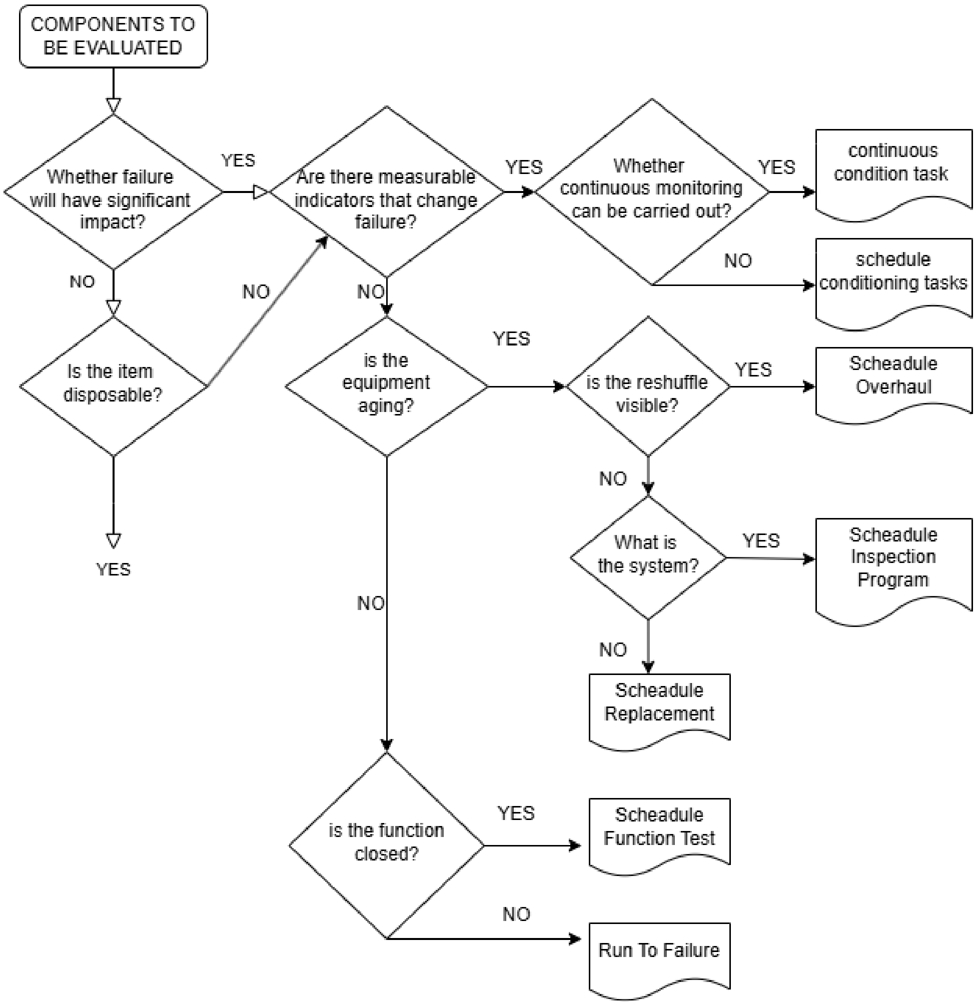

Fig. 2. Decision Logic Diagram

With this method, management can make policies and decisions on critical components to minimize the problems/risks.

Acknowledgments

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IMPACT OF THERMAL ENERGY ON SOLAR MODULE EFFICIENCY

M.F. Hanif [1], D. Rusirawan[2] and M. Božikova[3]

[1]Undergraduate Student of Mechanical Engineering, Institut Teknologi Nasional Bandung
[2]Departement of Mechanical Engineering, Institut Teknologi Nasional Bandung
Jl. PKHH. Mustapa No. 23 Bandung 40124, West Java, Indonesia
[3]Slovak University of Agriculture in Nitra
Trieda Andreja Hlinku 2, 949 76 Nitra
E-mail: muhammad.farhan@gmail.com

Solar energy is one example of renewable energy that can be converted into electricity using photovoltaic technology. Photovoltaic or solar modules are devices used to convert energy from solar radiation into electrical energy. Solar modules are one of the main components of solar power plants. Indonesia's geographical location is very strategic for utilizing photovoltaic technology because Indonesia is located on the equator where solar radiation is higher and relatively more constant compared to other countries with geographical locations far from the equator.

This study aimed to develop a thermal model for photovoltaic modules to minimize thermal energy that can reduce photovoltaic efficiency. Thermal energy should be minimized because it can affect photovoltaic efficiency and damage the solar module when the solar module temperature exceeds the nominal operating cell temperature (NOCT).

The thermal model of photovoltaic has several parameters that can affect efficiency, like convection, radiation, and ambient temperature, which can cause the solar module to increase in temperature inside the system due to heat transfer. During the photovoltaic conversion process, most of the incoming solar energy is converted to heat, with only a small portion converted into electricity, at higher solar irradiance and with high ambient temperature, the photovoltaic cells get overheated, the probability of failure of solar cell increases additionally reducing the output power and decline in the lifetime of the solar module, so the temperature of the photovoltaic module (T_m) is one of the most important factors which influence the effectiveness of electric power generation (Kirpichnikova et al., 2022). The layers of the basic construction of solar module can be seen in Fig. 1. The following equation for the temperature of the photovoltaic module (T_m) is:

$$T_m = T_a + \frac{NOCT-20}{800}\ G, \tag{1}$$

where NOCT (Nominal Operating Cell Temperature according to cell material), °C; Ta (ambient temperature), °C; G (solar irradiance), W/m^2.

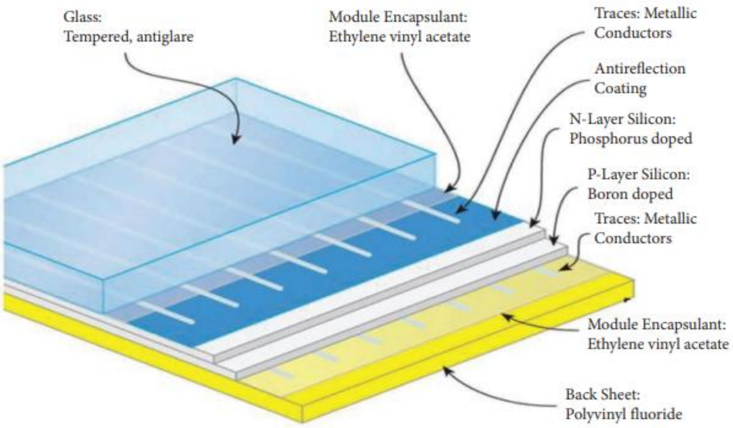

Fig. 1. Basic construction of solar module

Acknowledgments

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GREENHOUSE TEMPERATURE AND HUMIDITY MONITORING SYSTEM BASED IoT and ESP-NOW PROTOCOL

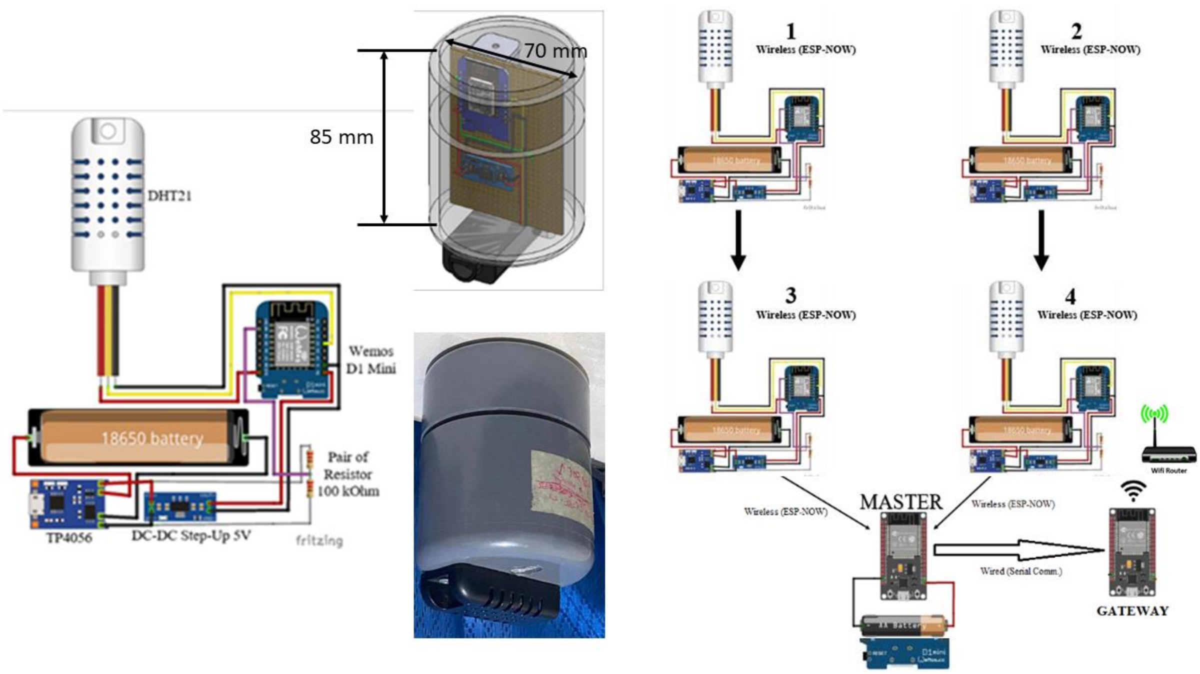
L. Hartawan[1], N. Nugraha[1], M. Iqbal[2], D. Rusirawan[1] and I. Farkas[3]

[1]Department of Mechanical Engineering, Institut Teknologi Nasional Bandung
[2]Undergraduate Student of Mechanical Engineering, Institut Teknologi Nasional Bandung
JL. PKHH Mustapa No. 23 Bandung 40124, Indonesia
[3]Institute of Technology, Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: liman@itenas.ac.id

The growth of plants in greenhouses requires appropriate environmental conditions, ~~in~~ particularly in suitable temperatures and adequate humidity (Gruber et al., 2011). Due to fluctuations in temperature and humidity within the greenhouse, it is necessary to take measurements at multiple locations.

This study aimed to develop multiple interconnected devices that can monitor air temperature and humidity wirelessly at a low cost. ESP-NOW is a communication protocol from Espressif, which allows two or more devices to communicate without using Wi-Fi and is available to ESP8266 and ESP32 board (Eridani et al., 2021). “Wemos D1 mini” is a development card~~s~~, for the data collection~~s~~, at a low cost (Ames et al., 2019).

The monitoring device, combining the Wemos D1 Mini and the DHT21 sensor, is known for its superior performance compared to the DHT11 or DHT22 sensors. It will be positioned at multiple locations within the greenhouse to measure the temperature and humidity in each specific area. Each monitoring device uses ESP-NOW protocol to establish a sequential connection from the farthest device to the nearest one. After all the data is collected on the microcontroller which acts as the recipient (master), the data will be sent to the Website via the Internet (Iqbal et al., 2024). The real concept of monitoring device can be seen in Fig. 1.



(a) (b)

Fig. 1. Temperature and Humidity Monitoring Device (a) Device & Components; (b) Data transfer Schematic

All components covered by PVC casing, each device contains Wemos D1 mini as microcontroller, DHT 21 as temperature & humidity sensor, two pair 100 kOhm Resistor for battery voltage sensor, one 18650 of battery, TP4056 as charging module, and DC-DC Step-Up 5V to power up microcontroller. This system has 4 (four) device that sequentially sending the data to the ESP32 as the MASTER, then collected data sent to another ESP32 via Parallel communication as GATEWAY to the Internet.

The results of the function test demonstrate that each device is capable of transmitting temperature, humidity and battery life data to MASTER, which is then displayed on the website. The PVC casing reduces the data transmission range to 30 - 45 meters, depending on the presence of obstructions between them. The accuracy of the temperature measurement is ±0,5°C and the accuracy of the humidity is ±3%. When in continuous operation, the current reached 78.67 mA.

Furthermore, field testing is required to determine the reliability of the system and utilise the sleep mode feature for the ESP microcontroller to reduce power consumption.

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IDENTIFYING GREEN AREAS BY "SATELITE" IMAGE ANALYSIS

A. Horel[1], Zs. Csaba[1], M. Magó[1] and I. Seres[2]

[1]Premontrei Szent Norbert High School,
[2]Institute of Mathematics and Basic Science,
Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: Seres.Istvan@phd.uni-mate.hu

A team of physics factoids from the Premontrei Szent Norbert High School created a student "satellite" for the Cansat 2024 competition. In addition to the mandatory tasks (temperature and barometric pressure measurement, radio communication), the "satellite" also had a GPS system so that they could find it. Its unique task was to determine the proportion of green surfaces in the area below the satellite based on the images taken during the flight - with the help of AI. The device successfully completed the test, and the team received a special scientific award for the work performed.

The main primary mission sensor of the CanSat called Seraph (see in Fig. 1) was a BMP280 sensor which measures air pressure and temperature during flight. The measured data was stored in the system to an SD card and transferred via radio every second to the ground station. The CanSat was equipped with a parachute that allows you to descend from back to the ground (from approximately 1 km height) at a speed of 7 m/s. The device also included GPS, which allowed to track the flight and helped finding the unit after landing. An Adafruit Feather microcontroller was used for in the main board. The sensors/devices were powered by a 3.7 V LiPo battery.

Fig. 1. The Seraph Cansat

For the green area rate measurement during the flight a mini HD camera (see in Fig. 2) was used, with independent power (built in battery and SD card), its type was SQ11.

Fig. 2. The SQ11 mini HD camera

The flight path of the satellite (see in Fig. 3) on a military rocket base on the Google maps during rocketed to the atmosphere (based on the measured GPS data).

Fig. 3. The flight path of the Seraph Cansat

The pictures taken by the satellite (see in Fig. 4) were analysed using our own AI, we built an AI in python. using the sklearn library in python. The AI was trained on different colours (rgb codes), and was given a value of 1 (true) if the given rgb colour code was green else it was given a 0 (false) we trained the AI on 680 data.

Additionally, our code outputs a text file, where we can see the picture in a way where the black area is where the picture is green, the rest is where it is not. This program can be used for finding roads and paths in nature, which can be a very useful tool.

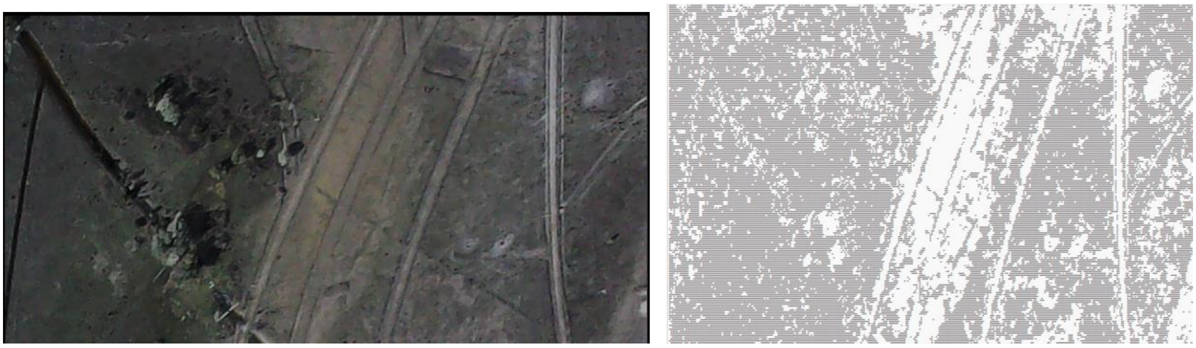

Fig. 4. Picture taken during the flight and the AI analysis about the green areas and roads

Acknowledgements

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https://www.instagram.com/seraph.sat/

MODELING THE DRYING KINETICS OF GOLDEN APPLE IN SOLAR SYSTEMS USING THIN LAYER EQUATIONS

H. Kidane[1], J. Buzás[2], and I. Farkas[2]

[1]Doctoral School of Mechanical Engineering, [2]Institute of Technology,
Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: Halefom.Kidane.Abrha@phd.uni-mate.hu

Solar drying is a reasonable option as it is free and environmentally friendly. The sun provides a clean and abundant source of renewable energy, which is harnessed and can be used numerous applications, such as solar heaters, photovoltaic systems, solar desalination, and solar dryers.

Energy sources, including renewables, often face interruptions or fluctuations that affect their reliability for end-users. In drying processes, such interruptions like solar energy being blocked by clouds or rain can significantly impact the drying period. Forecasting energy availability, especially for sources highly dependent on environmental conditions, like solar energy, is challenging.

Interruptions during drying result in varying drying profiles depending on the technique used. This necessitates selecting an appropriate drying model that can accurately evaluate and predict drying kinetics. Such a model should effectively account for the effects of interrupted or fluctuating conditions on the material's moisture loss behaviour.

So, it is important interpolating or predicting the process what was happening during the interruption. This is done using simulation or mathematical modelling.

The mathematical modelling of the drying process of agricultural products is a crucial tool that allows for the anticipation of drying efficiency, drying rate, drying behaviour, the reduction of time and costs in practical drying methods, and the development of suitable drying equipment and processes. This approach ultimately supports the optimization and advancement of drying technologies for agricultural products. Thus, accurate predictions contribute to ensuring optimal product quality and minimizing process time (Kaleta et al., 2013).

Thin layer equations offer a comprehensive framework for understanding the drying process, regardless of the controlling mechanism involved. They are utilized to estimate drying durations for different products and to create generalized drying curves (Toĝrul, Pehlivan D, 2004). An example of thin layer arrangement is shown in Fig.1.

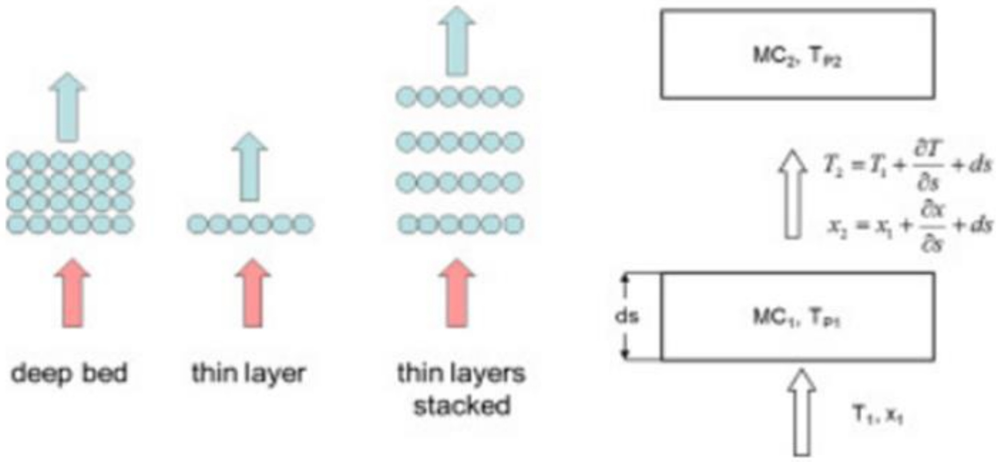

Fig. 1. Illustrative representation of deep bed, thin layer drying, and thin layer stacked (Sammy and Digvir, 2022)

The objective of this research is to **select mathematical models that can evaluate and predict drying kinetics of drying behaviour of golden apple under varying and interrupted conditions to improve process reliability.**

Numerous thin-layer drying models, such as Lewis, Page, Weibull, Midilli, logarithmic, and Henderson-Pabis, have been developed by researchers to describe the drying behaviour of various materials. Selecting the most suitable model for a specific application involves a systematic evaluation process. Initially, statistical parameters like the coefficient of determination (R^2), root mean square error (RMSE), mean bias error (MBE), and chi-square (χ^2) are calculated to evaluate each model's accuracy in representing experimental data. Subsequently, models are prioritized based on their statistical performance, with preference given to those demonstrating higher R^2 values and lower RMSE, MBE, or χ^2 values, depending on the selected evaluation criteria. Ultimately, the model that performs best in these assessments is chosen as the most appropriate for the material and drying conditions. This structured approach ensures precise prediction of drying kinetics, thereby optimizing the drying process for greater efficiency and effectiveness.

Acknowledgements

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MATHEMATICAL MODELLING AND EXPERIMENTAL VALIDATION OF DOUBLE-PASS SOLAR AIR COLLECTORS

Maytham H. Machi[1], I. Farkas[2], and J. Buzas[2]

[1]Doctoral School of Mechanical Engineering, [2]Institute of Mathematics and Basic Science,
[3]Institute of Technology
Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: maytham.hasan.mahdi.machi@phd.uni-mate.hu

Solar air collectors (SACs) are important tools for using solar energy, offering practical solutions for thermal energy applications. However, their low thermal efficiency has led to ongoing research aimed at improving their performance (Machi et al., 2022). Among the various innovations, double-pass solar air collectors (DPSACs) have become popular in renewable energy systems, especially for drying and heating. DPSACs improve thermal efficiency by reducing heat losses and increasing heat transfer compared to traditional SAC designs. This study focuses on evaluating the performance of DPSACs through a combination of experimental investigations and mathematical modeling to explore their potential for energy optimization.

The experimental setup, shown in Fig. 1, was installed at the Solar Energy Laboratory in Gödöllő, Hungary, and tested under outdoor conditions with two different mass flow rates (0.0103 kg/s and 0.01317 kg/s) and solar intensities up to 933.2 W/m². The DPSAC featured a copper absorber plate with a 5.5 cm upper channel and a 3.5 cm lower channel, equipped with insulation and airflow buffers for uniform distribution. Temperature, solar radiation, and mass flow rates were measured using precise instruments, including T-type thermocouples and a pyranometer (Machi et al., 2024).

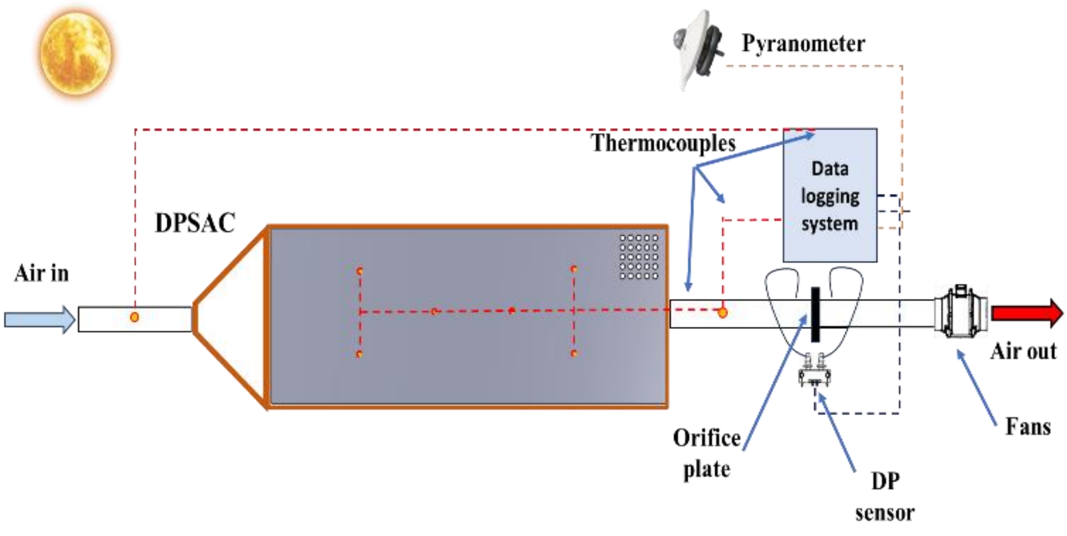

Fig. 1. Schematic view of the experimental setup

The mathematical model was developed based on energy balance equations for the glass cove, the absorber plate, flowing air, and insulation, as illustrated in Fig. 2. Validation against experimental results yielded R^2 values of 0.989 for outlet temperature and 0.917 for thermal efficiency, demonstrating the model's reliability. Results showed that thermal efficiency increases with mass flow rate up to 0.025 kg/s but begins to stabilize at higher flow rates due to reduced air residence time. Solar radiation effects were most significant at lower flow rates, highlighting the need for optimized airflow for balanced thermal performance.

This research highlights the robustness of the MATLAB-based model for designing and optimizing DPSAC systems, with significant implications for renewable energy applications such as drying and space heating. The scheme of the heat transfer coefficients and the thermal resistance network diagram are shown in Fig. 3.

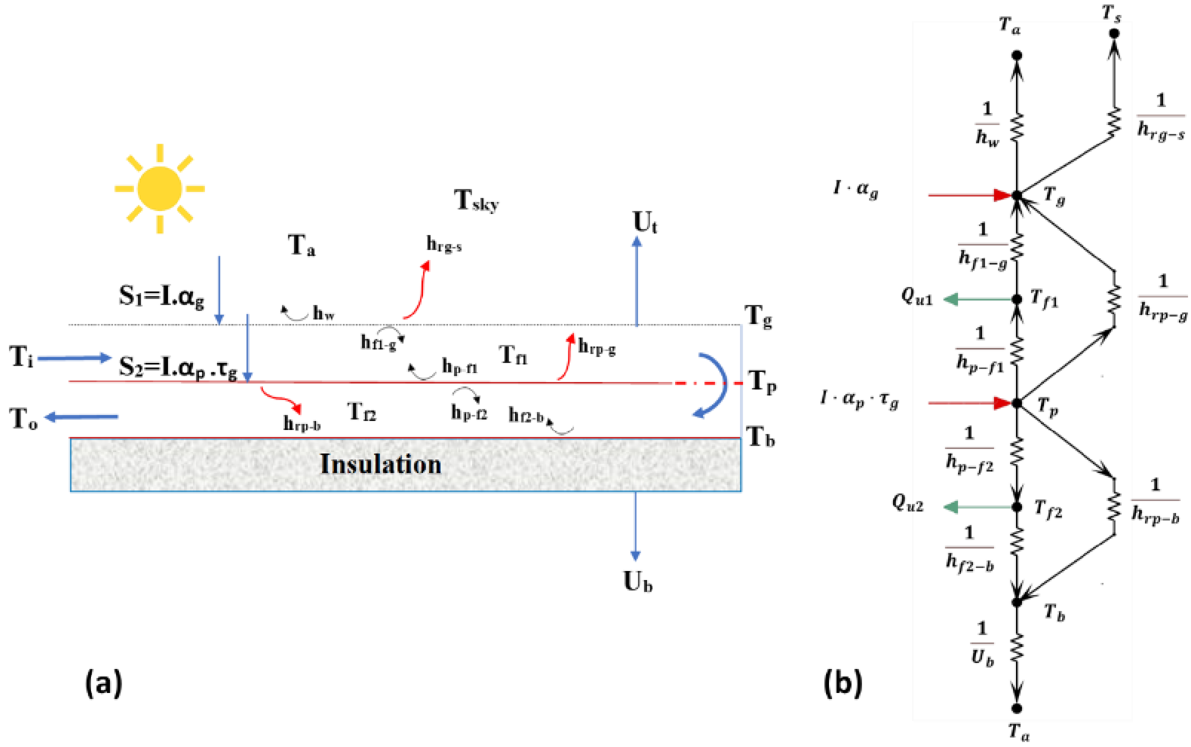

Fig. 3. Schematic view of: a) the heat transfer coefficient b) thermal resistance network diagram of a DPSAC

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AGRIVOLTAIC SYSTEMS: APPLICATION PURPOSE AND ITS CONTROL

D.S. Manopo[1], U.A. Albayumi[2], D. Rusirawan[3] I. Farkas[4]

[1]Graduate Student of Mechanical Engineering, Institut Teknologi Nasional Bandung
[2]Indonesia Aircraft Industry (PT. Dirgantara Indonesia), Bandung, Indonesia
[3]Dept. of Mechanical Engineering, Institut Teknologi Nasional Bandung
JL. PKHH Mustapa No. 23 Bandung 40124, Indonesia
[4]Institute of Technology, Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: deddy.sakti@mhs.itenas.ac.id

The application of agrivoltaic systems that combine agricultural activities with solar-powered energy production not only reduces dependence on fossil fuels but also increases land-use efficiency. The same land is dual-utilized for food and energy production through the installation of solar panels over agricultural areas. In addition, solar panels also serve as shade for certain crops, providing shade that can protect crops from excessive heat and reduce the risk of drought.

There are three concepts of agrivoltaic development. The first concept, which has been known since the 1980s, is the placement of solar panels between rows of bare land around crops. The second concept is to use a greenhouse structure, where solar panels are installed at the top with a certain distance between them and the third concept is to build a solar panel structure above the plants, also with a calculated distance so that sunlight can still reach the plants (Adrianto & Muhoir, 2024).

The purpose of this research is to evaluate the adequacy of energy to maintain soil moisture in agrivoltaic systems to support growth of various types of plants, optimally. Therefore, an experimental method is used where this research begins with several stages, namely the design of a solar power plant integrated with a pump to pump water to the irrigation system/watering plants. The design of agrivoltaic system can be seen in Fig. 1.

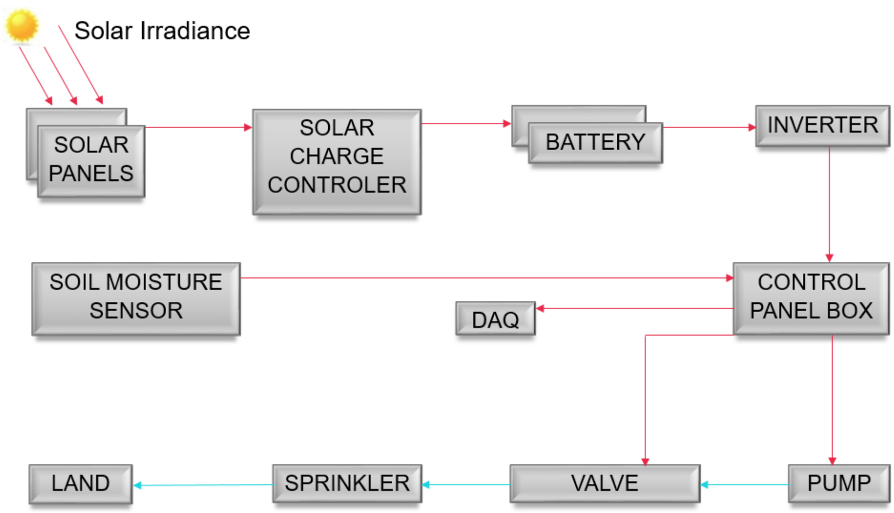

Fig. 1. Scheme of agrivoltaic system

The next step is making design a control system for watering. There are two watering control systems used, namely based on time using an RTC module and based on soil moisture using a Soil Moisture Sensor. There are disadvantages if only using one of the watering systems where the watering system that is only based on time does not meet the water needs for plants while the watering system based on humidity can cause plants to wilt if watering occurs during the day (Setiyawan et al., 2022). Therefore, in this research, an automatic control system is used for watering systems that work based on time at a certain time and based on soil moisture at a certain humidity level in accordance with the target humidity of plants, for that it will also take the ideal soil moisture conditions of several plants to be used as a reference for soil moisture targets. The design of the control system using both RTC and Soil Moisture Sensor modules can be seen in Fig. 2.

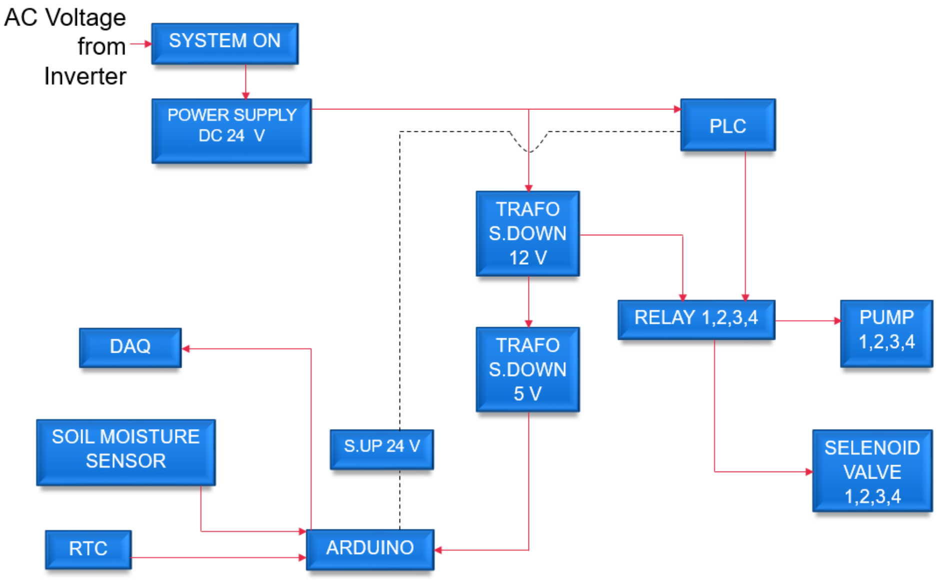

Fig. 2. Scheme of control system of watering

After designing the system, the selection of tools and materials is carried out, then the calculation of the humidity value that will be programmed in the control system is carried out, then testing is carried out, if successful the research is continued and if it fails, the program will be rewritten.

Furthermore, pump operation testing is carried out to obtain data on how long it takes for the pump to change the humidity to the desired humidity level, as well as how much water volume is needed and the power used by the pump will be calculated.

Based on this data, it will be analyzed how much energy this system needs to be able to work throughout the year if you want to plant one type of plant without being affected by seasonal changes because the humidity is maintained, and it can also be calculated the land area that can be accommodated by this system and the volume of water needed for the irrigation system on the land.

Acknowledgements

This research synopsis is released as an outcome of multidisciplinary international partnership between ITENAS Bandung, Indonesia and MATE Gödöllő, Hungary.

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EVALUATING THE ACCURACY OF SARIMA MODELS FOR SOLAR ENERGY PRODUCTION IN PV SYSTEM

M.D.A. Muluk[1], L. Lidyawati[2], D. Rusirawan[1], and I. Farkas[4]

[1]Department of Mechanical Engineering
[2]Department of Electrical Engineering, Institut Teknologi Nasional Bandung
Jl. PHH. Mustofa No. 23 Bandung 40124, Indonesia
[4]Institute of Technology, Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: dawamuddin17@gmail.com

Indonesia has great potential in utilizing solar energy. The potential solar energy source in Indonesia is around 4.8 kWh/m^2, or about 112,000 GWP. However, its utilization is still relatively low, around 24.42 MW (Sugiyono et al., 2019).

The solar power plant (SPP) converts solar energy by utilizing solar radiation, which is converted into electrical energy using photovoltaic (PV) modules. Several parameters or characteristics generated in a solar power plant are electric current (I), voltage (V), and power or energy (P) (Luque & Hegedus, 2011).

These characteristics are essential in determining the performance of the SPP. To obtain these parameters, it can be done by measuring directly to the module or data modeling. However, there are several obstacles when direct measurement is applied, therefore modeling is one suitable alternative to determine the SPP performance.

This study aims to evaluate the accuracy of a Seasonal Autoregressive Integrated Moving Average (SARIMA) model in predicting the energy production of a Solar Photovoltaic system. The model's performance will be assessed by comparing its SARIMA result to actual operational data.

This study using the operational data from a 1 kWp SPP installed at Institute Technology Nasional Bandung. By employing a SARIMA model and simulation will be performed in Jupyter Notebook with integrated Python 3.

SARIMA model uses the historical data to obtain estimated parameters of the SPP energy production. These historical data are taken from the cloud database, Aurora Vision, which monitors the daily energy production of a 1 kWp SPP at ITENAS Bandung. The installation of 1 kWp SPP at the ITENAS Bandung can be seen in Fig. 1 (Irdam et al., 2020).

Fig. 1. Installation of 1 kWp at ITENAS Bandung

The energy production data have been collected over time, however, the length of the data for modeling purposes has been defined as a sample, approximately one year. The historical data period used for modeling was June 5, 2020 – June 19, 2021. Fig. 2 shows a daily operation monitoring scheme of SPP's energy production.

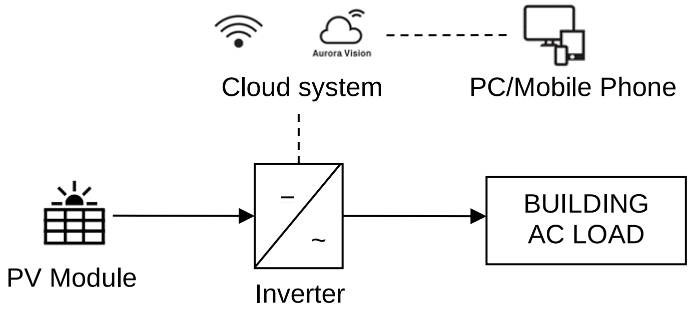

Fig. 2. Data monitoring of Solar Power Plant

To understand the performance of the model, evaluating the model needs to be done. The standard measures of forecast performance can be obtained by calculating mean absolute error (MAE) and root mean squared error (RMSE). Both methods measure the variability in the forecast error. In principle, both methods expected the error result of the forecast model to be close to zero (Montgomery et al., 2015).

Acknowledgments

This research synopsis is released as an outcome of multidisciplinary international partnership between ITENAS Bandung, Indonesia and MATE Gödöllő, Hungary.

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THERMAL MODEL OF PHOTOVOLTAIC MODULES: REALIZATION OF EXPERIMENTAL FACILITY USING ARDUINO MICROCONTROLLER

I. Mutaqin[1], U.A. Albayumi[2], D. Rusirawan[3] and I. Farkas[4]

[1]Undergraduate student of Mechanical Engineering, Institut Teknologi Nasional Bandung, Indonesia
[2]Indonesia Aircraft Industry (PT. Dirgantara Indonesia), Bandung, Indonesia
[3]Department of Mechanical Engineering, Institut Teknologi Nasional Bandung
JL. PKHH Mustapa No. 23 Bandung 40124, Indonesia
[4]Institute of Technology, Hungarian University of Agriculture and Life Sciences, Godollo, Hungary
Institute of Technology, Hungarian University of Agriculture and Life Sciences
E-mail: insan.mutaqin@mhs.itenas.ac.id

The main parameters of the photovoltaic (PV) module that affect the output power of the PV module are solar radiation (G), ambient temperature (Ta), and cell/module temperature (Tc). The output power of the PV module is greatly influenced by incoming solar radiation and cell temperature, which are directly affected by ambient temperature (Rusirawan & Farkas, 2011a). From various general characteristics of PV modules, it is found that at high temperatures and low radiation, the ability of PV modules to generate power tends to decrease. Additionally, an increase in the temperature of PV modules under constant radiation will reduce the power of PV modules. This phenomenon indicates that the power of PV modules is influenced by ambient temperature (Rusirawan & Farkas, 2011b). Presently, the performance of the PV module, which is represented by efficiency, ranges between 14-20%, especially for monocrystalline PV modules (Osanyinpeju et al., 2018).

PV modules' efficiency and performance are greatly impacted by thermal parameters (thermal model). However, other parameters that affect the PV module performances generally can be viewed also in other terms, i.e., optical model and electrical model.

In this study, the effect of heat on the PV module performance will be investigated. An Arduino microcontroller equipped with temperature, wind speed, and sun irradiance (or LDR) sensors will be used to evaluate the thermal effects on the PV. The schematic system to be realized is shown in Fig. 1.

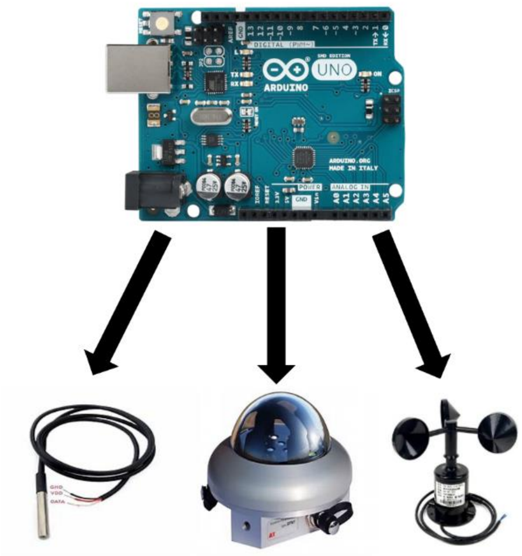

Fig. 1. Testing Sensor with Arduino

The built Arduino-based system turned out to be a dependable, cost-effective, and efficient monitoring tool for examining the effects of heat on PV modules.

Under carefully regulated settings, the experimental setup will be used continuously to measure important factors like temperature, irradiance, a wind speed, and will be conducted to the heat transfer phenomena. The created system will be designed for real-time monitoring and provide a dependable and affordable method for analyzing the thermal impact of PV modules.

Utilized of temperature sensor (DS18B20), a light intensity sensor (BH1750), and an anemometer for wind speed, can be used in prediction and determine how temperature and module efficiency are related. The developed system offers an economical and accurate solution for testing and monitoring the thermal effects on PV modules, making it applicable in renewable energy research and the development of more efficient PV systems.

Acknowledgments

The short synopsis of this research is released as an outcome of a multidisciplinary international partnership between ITENAS Bandung, Indonesia, and MATE Gödöllő, Hungary.

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SOLAR PV FORECASTING USING DEEP NEURAL NETWORK

T. Negash[1], I. Seres[2], I. Farkas[3]

[1]Doctoral School of Mechanical Engineering, [2]Institute of Mathematics and Basic Science,
[3]Institute of Technology
Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: Negash.Teklebrhan.Tuemzghi@phd.uni-mate.hun

Interest in solar energy, particularly solar photovoltaic (PV) systems, has been growing at an unprecedented pace, driven by advances in manufacturing technologies, improved efficiency, and significant cost reductions. These factors have made solar PV increasingly attractive as a key renewable energy source. Solar PV now accounts for a substantial portion of global renewable capacity, showcasing its pivotal role in the clean energy transition.

In 2023 alone, solar PV installations constituted three-fourths of the total renewable capacity additions, underscoring its dominance and rapid deployment (Abriendomundo, 2023). Despite its significant environmental and sustainability benefits, the large-scale integration of solar PV presents significant technical challenges for grid management.

The inherently intermittent and variable nature of solar generation poses difficulties in maintaining grid stability and reliability, particularly as penetration levels increase (Udayakumar et al., 2021). Addressing these challenges requires advancements in grid technologies, including energy storage systems, demand response strategies, and flexible grid design, to ensure that the transition to solar-dominated energy systems is both efficient and resilient. Several approaches have been proposed to address these challenges, including solar-wind complementarity, energy storage, and PV forecasting (Bajaj and Singh, 2020). These strategies enhance solar PV integration by smoothing fluctuations, storing and delivering electrical energy at different times, and enabling grid management strategies and scheduling.
Accurate PV forecasting remains a complex task despite advancements in predictive models, as solar generation is inherently variable and influenced by multiple weather parameters with nonlinear relationships to solar radiation (Abdel-Nasser and Mahmoud, 2019). Nevertheless, forecasting PV output across various time horizons offers significant advantages, such as mitigating operational challenges and reducing associated risks, thereby enhancing grid reliability and efficiency.

In this work, a deep neural network (Long Short-term Memory – LSTM) model is used to predict day-ahead hourly solar radiation, as shown in Fig. 1. This indirect method of solar PV generation has several advantages over direct PV generation forecasting. Indirect solar PV forecasting involves first predicting solar radiation, such as global horizontal irradiance, and then converting this data into PV generation using detailed physical models. This approach differs from direct solar PV forecasting, which predicts PV output directly from historical data, often using statistical or machine learning models. Indirect forecasting is more adaptable, as it does not rely on existing PV system data and can be applied to new or hypothetical installations by incorporating site-specific parameters like panel tilt, orientation, and efficiency.

Additionally, it offers an advantage in error analysis by separating inaccuracies in radiation predictions from errors in PV system modelling, allowing for targeted improvements in either domain. This method provides robust predictions that are unaffected by system upgrades or technology changes, making it ideal for planning and optimizing future solar energy systems. These benefits underscore its potential for reducing forecast errors and enhancing reliability, especially in scenarios requiring precise grid integration and policy planning.

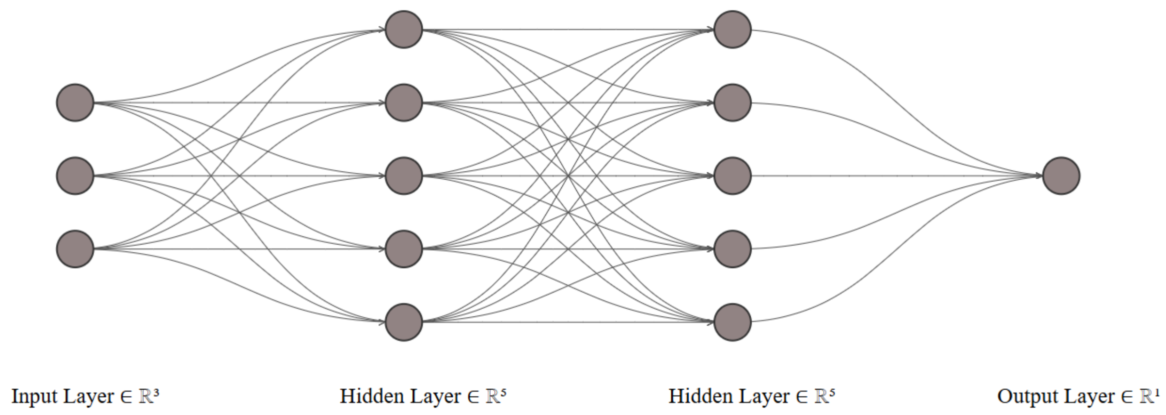

Fig. 1. LSTM network architecture, illustrating input, hidden and output layers

This study employs Long Short-Term Memory (LSTM) networks to forecast solar PV generation, leveraging their ability to capture complex, non-linear relationships between input and output variables. LSTMs have been widely utilized in forecasting solar radiation and PV generation across various time horizons due to their effectiveness in handling time series data. The LSTM model's forecast accuracy is compared against a Gated Recurrent Unit (GRU) model using multivariate inputs, including wind speed, solar angle, temperature, and solar irradiation data to benchmark its performance.

The results show that the LSTM model significantly outperforms the GRU model, achieving a root mean square error (RMSE) of 0.095 compared to GRU's 0.097. This highlights the LSTM's superior capability to capture long-term dependencies within time-series data, making it more effective for solar PV generation forecasting. This demonstrates the LSTM model's enhanced capability for accurate one-step-ahead PV generation forecasting, making it a reliable tool for renewable energy prediction.

Acknowledgment

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EDUCATIONAL EXPERIENCES ON THE LATEST RESULTS IN THE METROLOGY OF ALPHA EMITTING MATERIALS

I.R. Nikolényi, Z. Gémesi

Institute of Mathematics and Basic Science,
Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: Nikolenyi.Istvan.Robert@ uni-mate.hu

The transfer of new results in a scientific field and their integration into the educational system is a topical issue in the educational system, regardless of the country.
MATE, as a consortium partner of the recently completed European Union EMPIR 2020 19ENV02, RemoteAlpha project, has been exposed to a substantially new and breakthrough method of remote detection of alpha emitting particles based on optical principles (RemoteALPHA, 2020).

Thanks to the drone-based measurement system, unlike conventional instruments (Geiger-Müller counter, scintillation detector, and so on), which rely on direct detector-matter contact (which becomes indispensable due to the short range of alpha radiation in the air), it is possible in principle to detect large areas contaminated with alpha particles. This possibility is based on a secondary effect, the so-called radioluminescence phenomenon, where ionising radiation turns air into a light source (mainly in the UV range) (Baschenko, 2004).

Our Institute and Department have been teaching these new results in the framework of optional courses (so-called C-subjects) and have presented them to BSc students from home and abroad during professional-experience-learning days on military radiation detection methods (Nikolényi, Gémesi, 2024)

This presentation aims to give an overview of the main aspects of the teaching experience gained here. We intend to publish a more detailed analysis in a national journal on the teaching of physics, which could also be used in secondary education, in the near future.

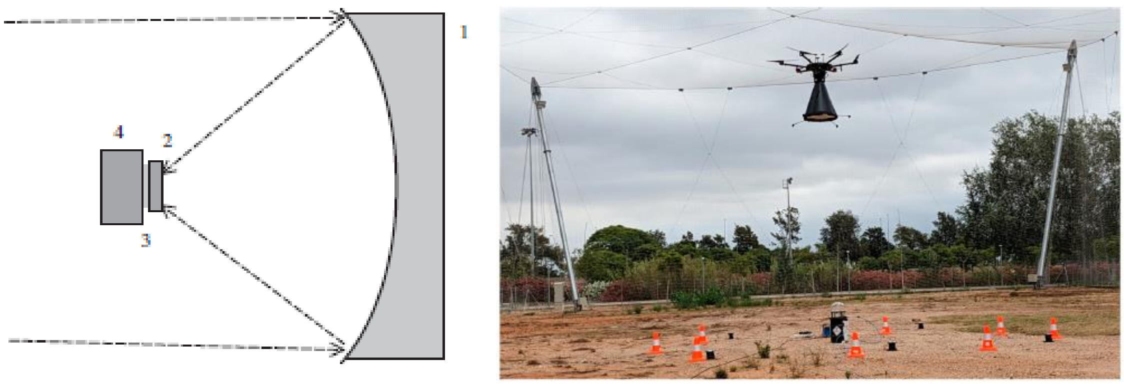

Fig. 1. (left) Baschenko's pioneering work in the field of optical principal detection. The spherical mirror-based receiver system captured an image of the ^{239}Pu, $3.7{\times}10^{7}$ Bq source from a distance of 30 m in total darkness on a film placed in focus. (Right) as a "final result" of the RemoteAlpha project, the Fresnel lens-PMT-based optical system installed on a drone at the drone laboratory of the UPS University in Barcelona, Spain (UPS's DroneLab), has for the first time detected Am-241 and 5 other UV-LED sources from several meters altitude in daytime conditions. The former required a special gas environment of the source (Royo et al, 2024).

Acknowledgements

The Authors would like to thank the partners of the EMPIR 2020, 19ENV02, RemoteAlpha project and its coordinator, Dr. Faton Krasniqi, for the very deep discussions over the past years. We would also like to thank the directors of IDEAS Science Ltd, CryDet Ltd, Dr. Györgyi Bela and Zoltán Csiki for their human and professional contribution to the project and the workshop days. We are also grateful to László Sodró 102nd Chemical Warfare Regiment of the Hungarian Armed Forces (formerly known as Görgey Artúr Chemical Protection and Information Centre, GAVIK) experts and their leader, Captain Zalán Mészáros for the practical and theoretical presentations of the professional days.

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ARTIFICIAL NEURAL NETWORKS ANALYSIS IN EXPERIMENTAL ORC RESULTS

D.I. Permana[1,2], D. Rusirawan[2] and I. Farkas[3]

[1]Doctoral School of Mechanical Engineering, [3]Institute of Technology
Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
[2]Department of Mechanical Engineering, Institut Teknologi Nasional Bandung
Bandung, West Java, Indonesia
E-mail: permana.diki.ismail@phd.uni-mate.hu

Organic Rankine Cycle (ORC) system emerges as an exceptionally efficient solution for converting low-grade thermal energy, making it particularly effective for decentralized power generation and versatile in various heat sources (solar (Permana et al., 2024), geothermal (Permana et al., 2021), biomass (Permana et al., 2023), and waste-heat recovery) at different temperature ranges. Unlike conventional Rankine cycles, ORC systems utilize refrigerants or mixed fluids as working fluids, characterized by lower boiling points than water and environmentally friendly properties. This enables efficient power generation at smaller scales and lower operating temperature (<200 °C).

While extensive experimental research has been conducted on ORC systems, challenges persist in accurately predicting unmeasured or unknown data and identifying optimal operating conditions. This study addresses these gaps using machine learning, specifically artificial neural networks (ANN). ANNs are self-learning, nonlinear methods capable of approximating complex functions, making them well-suited for predictive modeling in ORC applications (Daniarta et al., 2024). Moreover, the study adopts a multi-objective optimization framework to maximize net output work and thermal efficiency simultaneously. This sets a new standard for designing cost-effective, sustainable, and high-performance ORC systems. The outcomes of this research contribute to advancing predictive modeling for ORC systems, enhancing resource efficiency, and providing valuable insights for optimizing ORC operations in real-world scenarios.

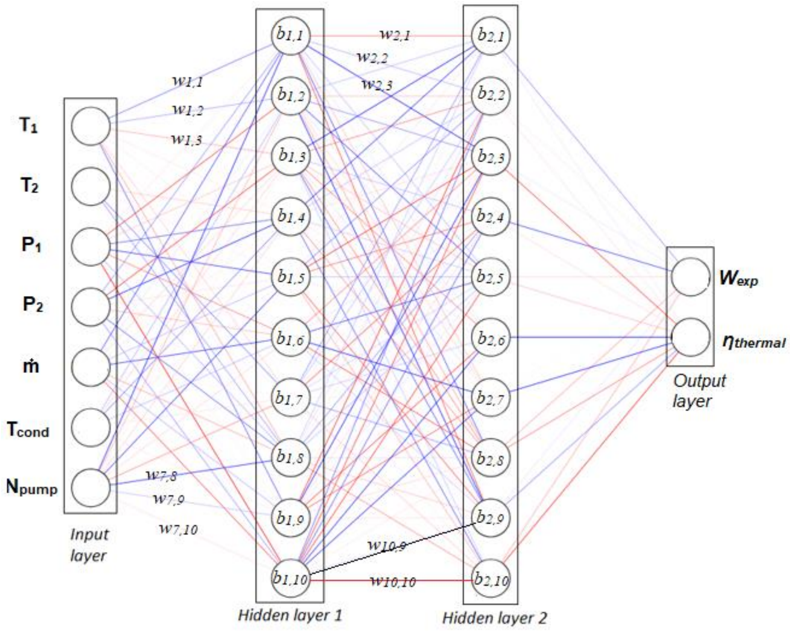

Fig. 1. ANN schematic for ORC

Finally, the output layer of the ANN represents the power output (W_{exp}) of a single scroll expander, while the thermal efficiency of the ORC ($\eta_{thermal}$) is illustrated in Fig. 1, depicting the structure of the neural network model. In this study, 102 experimental datasets were acquired and divided into two groups: 80% for training and 20% for validation. The partition of this data was decided. This paper uses ANN analysis to predict experimental results from an ORC prototype with a capacity of 2 kW from a waste heat recovery source. So in this research, the analysis of the two inputs, $\dot{m}$ and P_1, is the initial analysis to address how big the impact is on W_{exp} and $\eta_{thermal}$.

Acknowledgements

This work was supported by the Stipendium Hungaricum Programme and by the Mechanical Engineering Doctoral School, Hungarian University of Agriculture and Life Science, Gödöllő, Hungary and the Department of Mechanical Engineering, Itenas Bandung, Indonesia.

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INNOVATIVE INTEGRATION OF FLOATING PHOTOVOLTAIC SYSTEMS WITH HYDROPOWER

G. Pinter[1], A.S. Irshad[2], A. Mikhaylov[3]

[1]University of Pannonia, Faculty of Engineering, Soós Ernő Research and Development Center, Renewable Energy Research Group
[2]Department of Electrical and Electronics Engineering, Faculty of Engineering, University of the Ryukyus, Okinawa 903-0213, Japan,
[3]Financial Faculty, Financial University under the Government of the Russian Federation, Moscow 125167, Russia
E-mail: pinter.gabor@pen.uni-pannon.hu

This study introduces an innovative approach to achieving energy balance by integrating floating photovoltaic (FPV) systems with hydropower. This combination addresses not only environmental concerns but also the issue of underproduction in hydropower dams.

Solar photovoltaic power is quickly expanding its market share in the renewable energy sector due to its low cost and ease of deployment in a range of locations, and suitability for smart energy networks. There are also downsides to expanding solar energy. In warm climates, conventional ground-based PV systems encounter voltage losses due to heat, they require extensive land for installation. PV deployment is limited in many densely populated areas by the lack of large tracts of appropriate land for building massive solar arrays that can feed electricity into existing adjacent networks. Since most reservoirs are situated close to existing grid systems, putting FPV systems on them frees up space for other purposes, which is their main advantage. Additionally, certain systems benefit from the cooling effect of water, while FPV panels and floats reduce reservoir evaporation by reducing water temperatures by blocking radiation (Jin et al., 2023).

The examined hydro power plant is situated in Kajaki in Afghanistan, and its records for 2022 have been already published (DABS), revealing that the facility is powerless and that the current hydropower plant will never be able to meet load demand. During the winter season, from early December to the end of January, there is total load shading owing to a shortage of water. The greatest power that can be potentially injectedinto the distribution and transmission networks is 104.1 MW. While the combined load of the two cities and the surrounding area swings between 95 and 135.9 MW. The load was previously balanced by diesel generators located in Kandahar Breshnakot.

The annual energy required, and energy delivered to the grid by FPV-hydropower system is 986,070 MWh and 988,508 MWh, respectively. 2,438 MWh of the total energy generated by the FPV-hydropower system is wasted due to increased output by FPV that exceeds the load.

The FPV system produces 287,637 MWh, or 29% of the entire energy generated by renewable sources (see on Fig. 1).

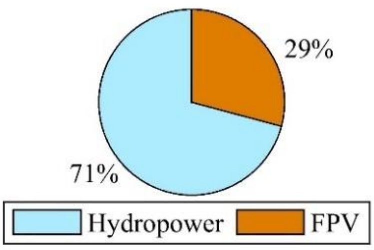

Fig. 1. Energy share of hybrid system

The hydropower system provides the remaining 698,433 MWh, or 71% of the total energy provided. The energy produced by the FPV for the whole year under consideration for our analysis is over 290,000 MWh. From this amount of energy, 2,438 MWh is lost due to surplus power produced by FPV over the load depicted in Fig. 2. Most of the energy loss occurs during the hot season, when the amount of power produced by the FPV system is high and passes the load curve.

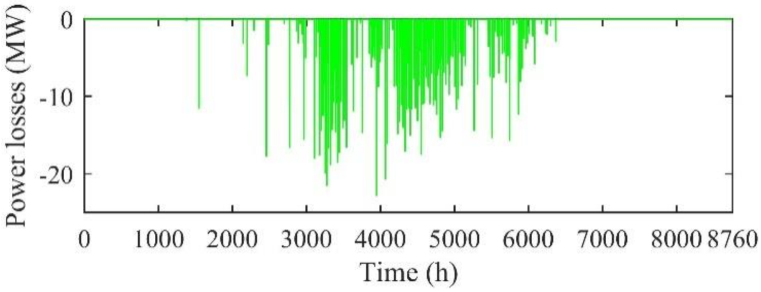

Fig. 2. Annual FPV power losses

The hydropower plant exhibits reduced energy production during periods of sufficient solar irradiation, when the FPV system is operational. In this simulation, the total energy generated by the hydropower equals the energy that could have been produced during prior instances with a significant disparity between load and hydropower production. This is attributed to the fixed power dispatch point, necessitating the optimal utilization of FPV capacity. On days without sunlight, hydroelectric power serves as both the base and peak power dispatch point, bridging the gap between load demand and FPV output throughout the day.

The key findings of the study are listed below:

- Alternative energy balancing: The study explores an alternative approach to balancing energy demand by integrating Floating Photovoltaic (FPV) systems with hydropower.
- Under typical circumstances, base power generation is powered by huge water flow through turbines. Too much water is used when hydropower facilities have to meet full demand.
- Land and water preservation: The 166.3 MW FPV system, installed on water, covers 1.68 km^2 of water surface, which reduces land usage for solar installation. The FPV installation reduces water evaporation by 6,242,880 m^3 annually.
- Environmental impact: The FPV system contributes to an annual reduction of 238,739 tons of CO_2 emissions, highlighting its environmental benefits.

Acknowledgements

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EXPERIMENTS AND NEW PHYSICALLY-BASED MATHEMATICAL MODEL FOR A RECENTLY INVENTED SOLAR POT

M. Rátkai[1], G. Géczi[2], R. Kicsiny[3], and L. Székely[3]

[1]Doctoral School of Mechanical Engineering, [2]Institute of Environmental Sciences,
[3]Institute of Mathematics and Basic Science
Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: Ratkai.Marton.3@phd.uni-mate.hu

The thermal energy provided by the sun is used to treat food in different ways. Examples include drying (Kalita et al., 2024), baking and cooking (Mehling, 2023). Solar food preparation devices are known which can produce the temperature required for safe cooking. According to USDA (2024), this temperature value is 73.9°C. Among these devices, there are indirect type cookers. They use a solar collector to produce the thermal energy needed for food processing.

The studied solar pot (Fig. 1) is an indirect cooker. It is a recent invention, which is made for environmentally friendly cooking or heating of foods and liquids (by utilizing solar energy). Its structure is similar to a double pipe heat exchanger, it has an outer mantle and an inner cooking tank (Géczi, Kicsiny, 2021).

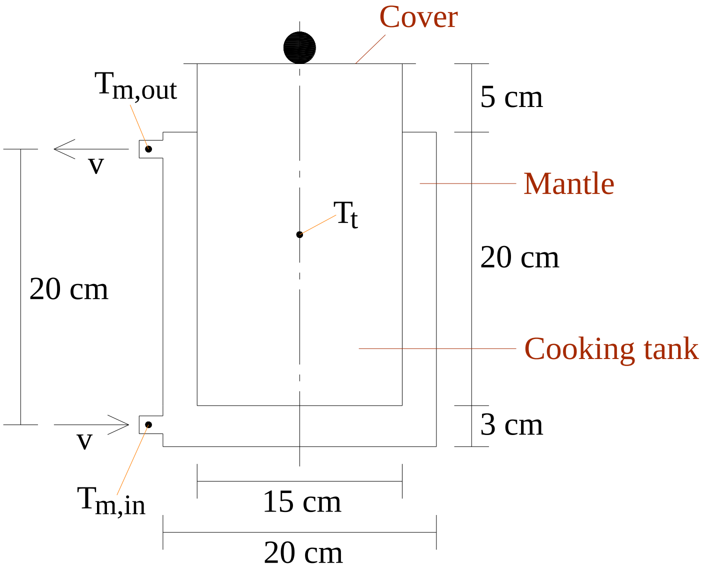

Fig. 1. Sizes and measuring points of the solar pot

The goals of the paper are proposing a new physically-based mathematical model describing the recently invented solar pot, and carrying out computer experiments with it, based on which conclusions are drawn regarding the practical applicability of the solar pot. Furthermore, assembling an experimental system of the hydraulically connected solar pot and a solar collector, and performing measurements on it. Based on measured data, conclusions are drawn regarding the practical applicability of the solar pot.

The model of the solar pot is based on the energy balance of the pot. It consists of two submodels (due to the jacketed structure of the pot), one for the mantle temperature and the other for the cooking tank temperature, constituting a system of differential equations. Both equations are non-homogeneous linear differential equations with constant coefficients. The model uses temperature differences only, which allows the use of either Celsius or Kelvin values. The model is used to run computer simulations with two different volumetric flow rates. The experimental system of the solar pot and the solar collector is located at the Szent István Campus of the Hungarian University of Agriculture and Life Sciences (Gödöllő, Hungary), on which measurements are made. During the measurements the same flow rates are used as in the simulations.

Based on both the simulated and the measured results, the solar pot can successfully be used to cook or sterilize different foods and liquids during the studied time period, in Hungary. In particular, based on measured data, the temperature level needed for heat treatment (raised to 75 °C due to safety purposes) can be maintained in the cooking tank for several hours (~5 hours, on the average) in a typical day in May.

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ORGANIC RANKINE CYCLE SYSTEM WITH REFRIGERANT FLUID R-134A: EVALUATION OF AN EXISTING EXPERIMENTAL FACILITY

Rifansyah[1], D.I. Permana[2,3], D. Rusirawan[2], I. Farkas

[1]Undergraduate Student of Mechanical Engineering, Institut Teknologi Nasional Bandung
[2]Department of Mechanical Engineering, Institut Teknologi Nasional Bandung
Jl. PHH. Mustopha No. 23 Bandung 40124, Indonesia
[3]Doctoral Study of Mechanical Engineering, Hungarian University of Agriculture and Life Sciences
[4]Institute of Technology, Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: rivansyah6166@gmail.com

Power generation from low-temperature energy technologies, especially with energy resources from solar energy, geothermal, and low-temperature waste heat, are gaining popularity due to their environmentally friendly nature. These low-temperature energy sources are generally within the temperature range of 80 °C to 150 °C. Organic Rankine Cycles (ORC) have been recognized as the most promising thermal system for generating electricity from these low-temperature heat sources (Herath et al., 2020).

The ORC is a system that converts heat into mechanical energy or work. In this cycle, the working fluid used is an organic fluid or refrigerant. The use of this type of fluid aims to utilize lower-temperature heat sources, as organic fluids generally have lower boiling points. This allows the evaporation process to occur at lower temperatures compared to water or other conventional fluids (Herath et al., 2020).

The four primary parts of a basic ORC system are a pump, an evaporator, a condenser, and an expander or turbine. Heat reservoirs with high and low temperatures are the evaporator and condenser, respectively. The turbine produces a beneficial exercise from the cycle, while the pump simultaneously circulates the working fluid throughout the system's components. The organic working fluid used is R134a, as seen in Fig. 1.

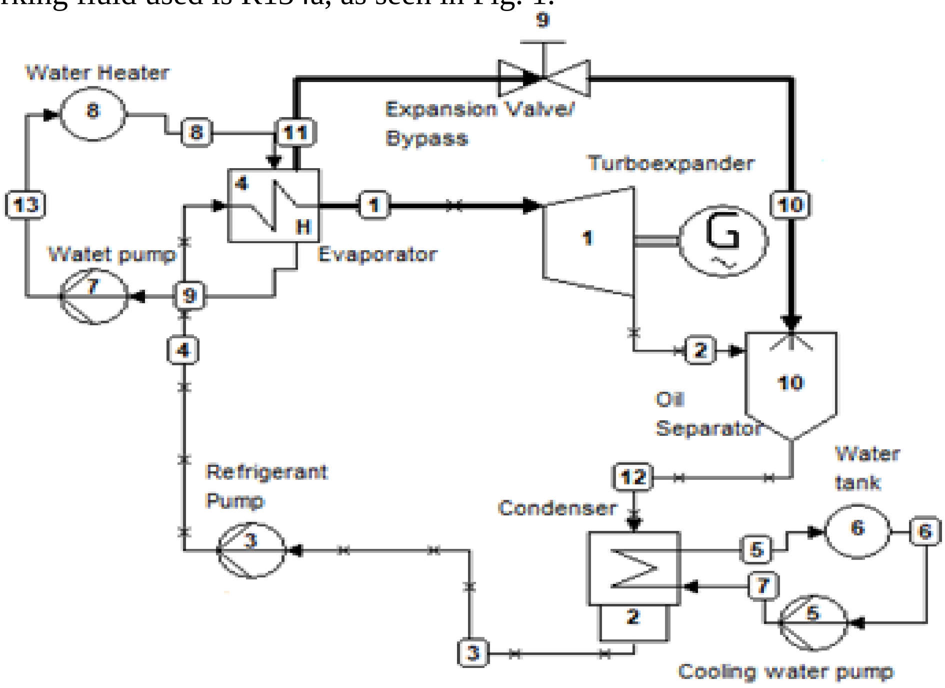

Fig. 1. Schematic design of the Organic Rankine Cycle system

The pump pushes the working fluid R-134a into the evaporator. In the evaporator, the temperature and pressure of the working fluid R-134a are increased, causing the pressurized working fluid R-134a to be directed to drive the turbine. The turbine is connected to a generator that will produce electrical energy. The working fluid R-134a enters the condenser to lower its temperature and pressure, and then the working fluid R-134a returns to the pump.

This ORC uses the working fluid Refrigerant R-134a due to its lower Global Warming Potential (GWP) and Ozone Depletion Potential (ODP), as seen in Table 1.

Table 1. Refrigerant Properties

Refrigerant Properties		
Property	**R-1234ze**	**R-134a**
Boiling Temp.	-2 °F (-19 °C)	-15 °F (-26 °C)
Critical Temp.	229 °F (109 °C)	214 °F (101 °C)
Critical Pressure	527 PSI (36 bar)	589 PSI (40.6 bar)
Global Warming Potential (GWP)	<10	-1300
Ozone Depletion Potential (ODP)	0	0
ASHRAE Safety Group	A2L	A1

The development process of the existing ORC system will be modified by replacing the cooling compressor with a turbine that functions as an expander in the system. This turbine will then be connected to a generator to enable testing of the entire system, allowing it to produce electrical energy (Muttawakil, 2024).

Acknowledgments

This research synopsis is released as an outcome of multidisciplinary international partnership between ITENAS Bandung, Indonesia and MATE Gödöllő, Hungary.

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STUDY COMPARISON OF CHARACTERISTICS OF 50 Wp MONOCRYSTALLINE PHOTOVOLTAICS WITH AND WITHOUT COATING: INITIAL EXPERIMENT

M.D. Royandi[1], T. M. Hasibuan[1], N. Nugraha[2], D. Rusirawan[2], F. Hadiatna[3], D. Fauziah[3], I. Farkas[4]
[1]Undergraduate Student of Mechanical Engineering, Institut Teknologi Nasional Bandung
[2]Departement of Mechanical Engineering, Institut Teknologi Nasional Bandung
[3]Departement of Electrical Engineering, Institut Teknologi Nasional Bandung
Jl. PHH. Mustofa No. 23 Bandung 40124, Indonesia
[4]Institute of Technology, Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: muhammad.dicky@mhs.itenas.ac.id

Photovoltaics (PV), which are typically installed outdoors, are exposed to rain and dust particles that can adhere to the surface and form crusts. These crusts and dust particles reduce the efficiency and electricity production capacity of solar power systems (Shengxian et al., 2021). Regular cleaning of photovoltaic panels incurs significant costs and is challenging, especially as these systems are often installed on rooftops or elevated areas.

Previous studies have explored solutions to prevent dust and rainwater stains on photovoltaic panels by coating them with hydrophobic materials. These coatings make it easier for dust to be blown off the panel's surface by the wind. A previous study designed and built a testing apparatus to compare the performance and phenomena between coated and uncoated photovoltaic panels (Hasibuan et al., 2024).

The solar power generation device components are shown in Fig. 1, where 1. Solar modules, 2. Electrical actuator, 3. Solar charge control, 4. Battery). The used photovoltaic panel is monocrystalline types with a capacity of 50 Wp including two modules, and supported by actuators with an extension motion length of 300 mm. The actuators are utilized to adjust the angle of the solar panels and are powered by a 12 V battery. The wiring diagram of the set-up is shown in Fig. 2.

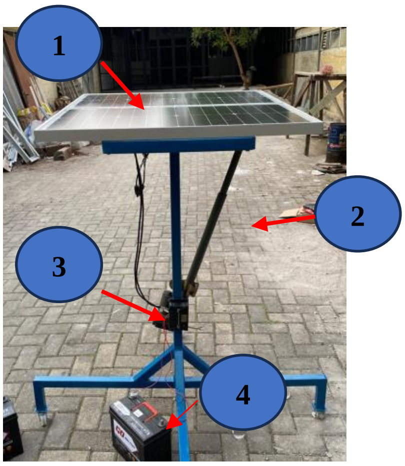

Fig 1. Solar power generation device

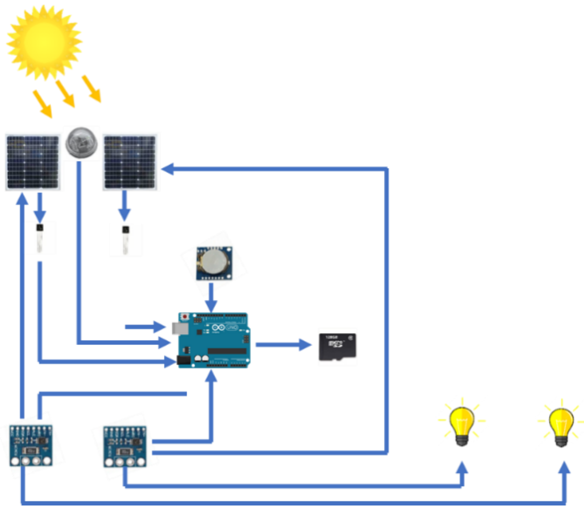

Fig 2. Wiring diagram

The purpose of this study is to install the necessary sensors to collect testing data, followed by conducting tests to observe the phenomena and performance of each photovoltaic panel and compare them.

The sensors used in this study are shown in Fig. 3 and are controlled by an Arduino Uno. Sensor 3a measures light intensity, sensor 3b measures temperature, sensor 3c captures current, voltage, and power data, and sensor 3d serves as a time sensor to collect data every minute. The data from the sensors are sent to the Arduino Uno and stored on a memory card.

Fig 3. The used sensors: (a) SEN0390 (b) DS18B20 (c) INA226 (d) RTC DS1307

The testing will involve collecting data on power, temperature, voltage, current, and light intensity for both photovoltaic panels, one coated with a hydrophobic layer and the other uncoated. The efficiency of each panel will then be calculated, compared, and analysed.

Data collection will be conducted at tilt angles of 30° and 45°, as per the Indonesian National Standard (SNI), which specifies that the standard and acceptable roof tilt angle for residential buildings is 45° or less. This tilt angle reflects the structural strength against wind pressure, live loads, dead loads, and other forces. The tilt adjustment will be controlled using an actuator.

Acknowledgments

The short synopsis of this research is released as an outcome of a multidisciplinary international partnership between ITENAS Bandung, Indonesia, and MATE Gödöllő, Hungary

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A PORTABLE SOLAR-POWERED TELESCOPIC LAMP: DEVELOPMENT OF PROTOTYPE

D.G. Subagio[1,2], Y. Radiansah[2], A. Rajani[2], R.A. Subekti[2], A. Fudholi[2,3], K.H. Sanjaya[4], H.M. Saputra[4], M.A. Putra[5], D. Rusirawan[5]

[1]Graduate Student of Mechanical Engineering, Institut Teknologi Nasional Bandung
[2]Research Center for Energy Conversion and Conservation, National Research and Innovation Agency (BRIN), Bandung, Indonesia
[3]Solar Energy Research Institute, Universiti Kebangsaan Malaysia,
43600 Bangi Selangor, Malaysia
[4]Research Center for Intelligent Mechatronics, National Research and Innovation Agency (BRIN), Bandung, Indonesia
[5]Dept. of Mechanical Engineering, Institut Teknologi Nasional Bandung
JL. PKHH Mustapa No. 23 Bandung 40124, Indonesia
E-mail: dalmasius.ganjar@mhs.itenas.ac.id

This research is focused on the development a high efficiency of portable solar-powered telescopic lamp. The telescopic lamp is designed with a simple and multifunctional design because apart from lighting it can also be used for charging cell phones, and easy to carry or move because the entire construction can be inserted into a pipe tube (Rajani, Ahmad et al., 2019).

This telescopic lamp is designed with a simple and portable construction. All components of the lamp can be stored in a plastic tube, making transportation easy. The main components of this lamp include a solar cell, lithium battery, LED strip, USB port, and DC plug. The solar cell used has a specification of 5 V 220 mA, and six 18650 lithium batteries are arranged in parallel as shown in Fig. 1. An illustration of the telescopic lamp assembled in a plastic tube is shown in Fig. 2, while the block diagram is shown in Fig. 3.

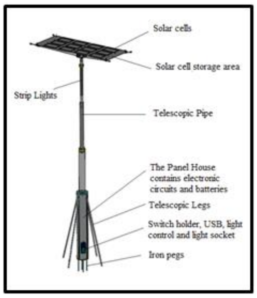


Fig. 1. Telescopic

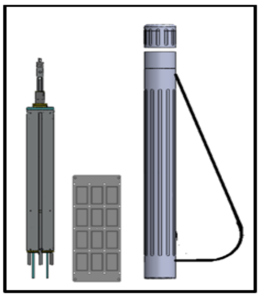


Fig. 2. Plastic tube

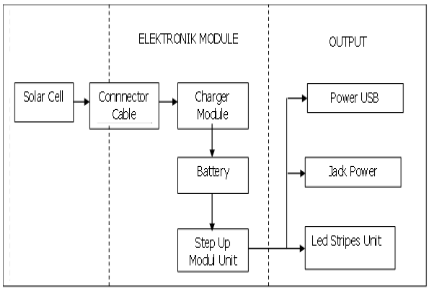


Fig. 3. Block diagram

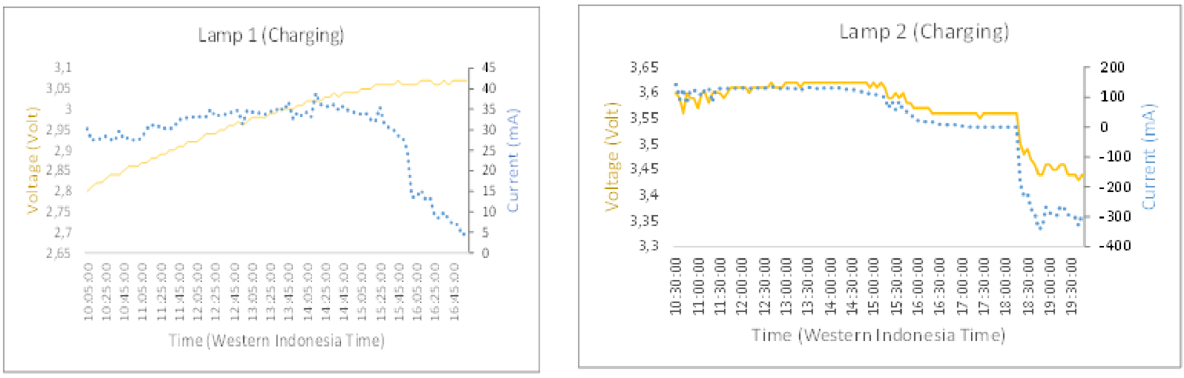
Laboratory tests of a solar-powered telescopic lamp have been published previously by Sanjaya et al., 2021. The light consists of a solar cell, lithium battery, LED strip, female USB port, and female DC power plug. 5 V 220 mA solar cells and six 18650 lithium batteries are arranged in parallel as well as other construction parts.

The trial has been carried out, and based on several tests, it is found that the efficiency values obtained were still low, namely 6.28%, 8.52% and 7.7%, lower than around 10%-25% compared to the previous research (Green, et al., 2010).

Field testing of our prototype was conducted on Ayer Island, in DKI Jakarta Province (see in Fig. 4). The testing aimed to evaluate the performance of the solar-powered lighting system under everyday usage conditions. The testing process included charging the battery via solar cells from 10:00 AM to 5:00 PM, as well as testing the lamp usage from 7:30 PM to 6:00 AM. Data on battery voltage and current were recorded for further analysis.

Fig. 4. Field test on Pulau Ayer beach, near Jakarta

Data on changes in voltage and current are recorded every second. However, the graph displays data per 20 minutes. The changes in battery voltage and current are illustrated in Fig. 5 (a & b). The yellow line represents voltage, and the dotted blue line represents the current.



(a) (b)

Fig 5. Charging test results in field tests on Ayer Island: (a) lamp 1; (b) lamp 2

The test results indicate that the telescopic lamp functions well according to the plan. However, the efficiency obtained is still lower compared to previous research, which reported circuit efficiency reaching over 80% (Green et al., 2010). Therefore, further improvements and developments are needed to enhance the efficiency of the system.

Acknowledgements

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CYLINDRO-PARABOLIC COLLECTOR: THERMAL AND DESALINATION ENHANCEMENTS

F. Touaref[1], I. Seres[2] and I. Farkas[3]

[1]Doctoral School of Mechanical Engineering, [2]Institute of Mathematics and Basic Science,
[3]Institute of Technology
Hungarian University of Agriculture and Life Sciences
Pater K. u. 1., Gödöllő, H-2100, Hungary
E-mail: Touaref.Fares@phd.uni-mate.hu

The scarcity of freshwater is a pressing issue, especially in arid regions. Solar desalination offers a sustainable solution, but conventional systems are often large, complex, and costly. This study introduces a portable thermo-solar cylindroparabolic (CPC) system with solar tracking and an off-grid design, enhancing efficiency and reducing costs (Touaref et al., 2024). Computational Fluid Dynamics (CFD) shows that an elliptical absorber improves heat transfer by 15% compared to traditional designs.

The implementation operates a CPC solar collector with solar tracking technology, integrated with MPPT technology via an Arduino UNO. It is connected to a data logger, micro-computer, and electronic board for continuous solar tracking, powered by 5 V during the morning period (when the sun is present). For nighttime operation, thermal electric generators at the thermal receiver are powered by a 12 V solar battery in a hybrid system. A cleaning system ensures the setup is ready for sunrise, with platinum used for the thermal receiver and aluminium for the thermal reflector, optimizing thermal solar energy efficiency. Additionally, the system includes a thermal storage and water filtration system (pH control). A diagram illustrating the testing setup equipped with sensors is shown in Fig. 1.

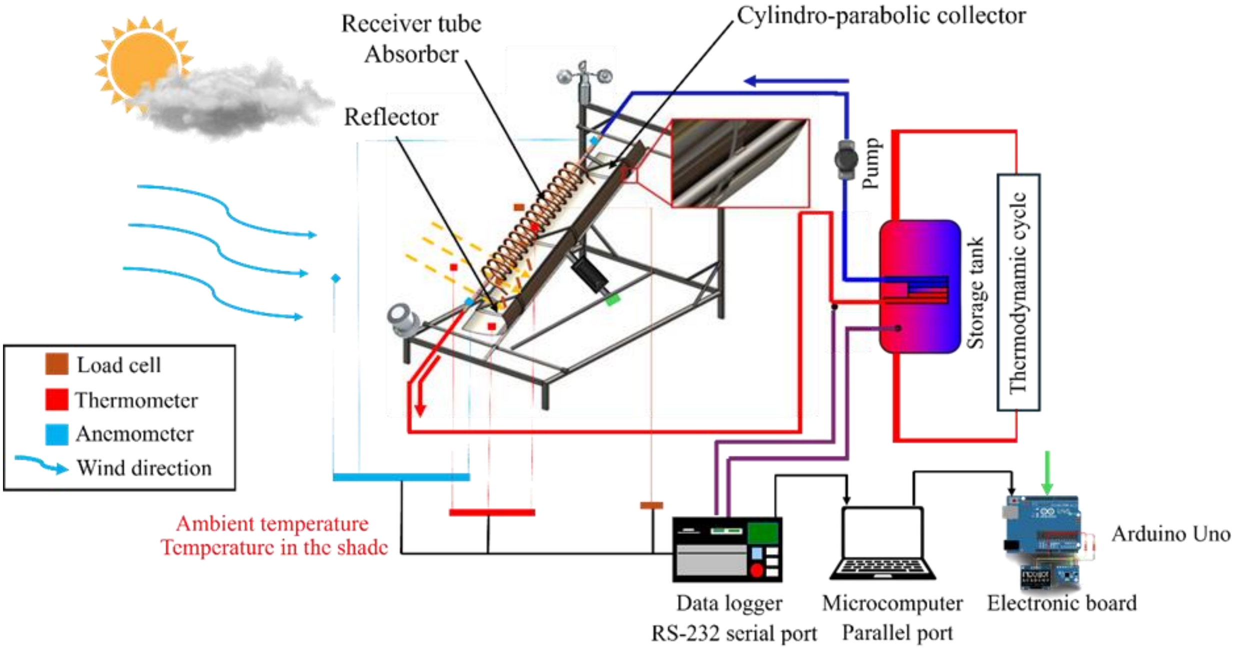

Fig. 2. The schematic of the testing conditions with sensors

This study employs a simplified model of the parabolic trough receiver, where the influence of the central rod and other supports is deemed negligible. Fig. 2 presents a detailed schematic diagram of the receiver, with borosilicate glass used for the glass cover and steel for the absorber tube. The annular space between both tubes is assumed to be a vacuum at very low pressure and ambient temperature.

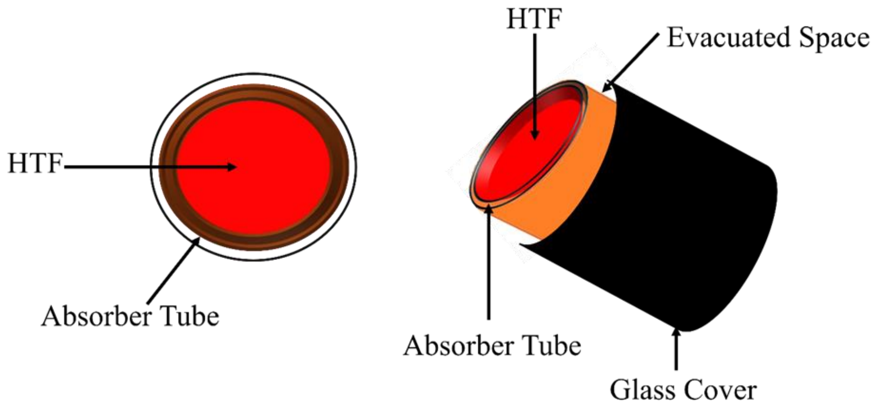

Fig. 3. Schematic of PTC receiver and model configuration

Finally, this study numerically investigates cylindrical and elliptical absorber tubes in a solar collector, showing that the elliptical design significantly improves heat transfer. The elliptical absorber's performance, confirmed by higher Nusselt numbers and Performance Evaluation Criterion (PEC) values, aligns closely with experimental data. Additionally, an innovative portable CPC with solar tracking and a hybrid system for desalination demonstrates consistent water yield, highlighting solar energy's potential in addressing freshwater scarcity.

Acknowledgements

This work was supported by the Stipendium Hungaricum Programme and by the Mechanical Engineering Doctoral School, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary.

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ORGANIC RANKINE CYCLE DRIVEN BY A SOLAR THERMAL SYSTEM

M. Usman[1], J. Buzás[2] and I. Farkas[2]

[1]Doctoral School of Mechanical Engineering, [2]Institute of Technology
Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: Usman.Mannir@phd.uni-mate.hu

Energy generation plays a crucial role in the economic and social progress of any nation. With the growing population, industrialization, urbanization, and expanding global trade and production activities, the demand for natural resources and energy continues to rise daily. As a result, the significance of renewable energy sources has become more prominent, especially in light of the heavy reliance on fossil fuels for energy consumption.

Conventional power generation systems, such as a steam-based Rankine cycle, need substantial energy input. Despite extensive fuel consumption their efficiency is very low. Current ecological regulations demand more nature-friendly solutions, with lower CO_2 emissions, and more efficient use of the supplied energy **(Zhang et al., 2016).**

Solar thermal energy is the most available energy resource that can be found everywhere in the world; this makes its integration with Organic Rankine Cycle (ORC) technology crucial for energy generation (Baral et al., 2015). The benefit of powering organic rankine cycle technology with solar thermal energy is that it can provide clean energy at an affordable rate in countries like Hungary (Baral et al., 2015; Zhang et al., 2016).

The ORC technology has been considered among the most promising and practical solutions that can covert low temperature heat sources in the electrical power industry due to its reliability, simple structure, easy maintenance cost (Quoilin et al., 2013).

The aim of this research is to determine the optimal design for harnessing organic Rankine cycle (ORC) integrated with solar thermal systems, such as solar collectors. The study will comprise the utilization of both simulation and experimental analysis by using different organic working fluids and operating conditions. The analysis will focus on both thermodynamics and economic perspective.

Fig. 1 shows the schematic diagram of the direct Solar-ORC cycle that uses solar thermal energy as a heat source. The system comprises five basic components, namely, the expander (turbine), condenser, pump, heat exchanger, and solar thermal system.

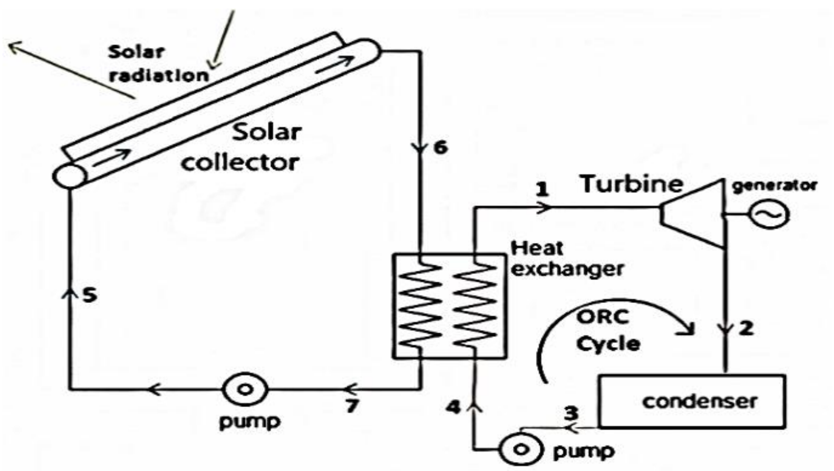

Fig. 1. Schematic diagram of a solar Organic Rankine Cycle

The system is composed of two cycles: the solar cycle and the ORC cycle. In the solar cycle, water is heated by solar thermal systems, such as solar collectors. The heat exchanger, which connects the solar cycle and the ORC cycle, transfers heat from the hot water to the working fluid, turning it into vapor. This vapor causes the turbine to rotate, generating electricity through the generator linked to it.

Acknowledgements

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SPECTRUM ANALYSIS OF LIGHT REFLECTED FROM SOLAR CELL

P. Vig

Department of Physics, Institute of Mathematics and Basic Science,
Hungarian University of Agriculture and Life Sciences, Páter K. u. 1., Gödöllő, H-2100 Hungary
Tel.: +36 28 522055, E-mail: Vig.Piroska@uni-mate.hu

The widespread use of renewable energies, including solar energy devices, is an important opportunity to address today's energy problems and combat environmental pollution. Solar cells are particularly important among these because they are not a mature technology; the efficiency of solar cell technology can be increased by applying the latest achievements in solid-state physics and nanotechnology, and in addition, the application of developed thin-film coatings also offers the opportunity to take other special aspects and needs into account (Aratbazis et al., 2018; Aghababai and Jabbari, 2022; Sarkin et al., 2020).

When solar modules are placed in the environment, they modify the environment physical parameters, colour, air flow conditions, temperature and light conditions. The present research focuses on the latter, examining how the intensity of light reflected from a polycrystalline solar cell change as a function of wavelength and how it depends on the angle of incidence of the light reaching the solar cell. The final goal of the study is to compare the reflexivity of the examined solar cell and water surface.

The tested solar cell is a 4 W polycrystalline solar cell without special coating. The spectrum analysis was carried out with the Ocean Optics spectrometer shown in the figure.

The calibrated spectrometer allows the measurement of the number of incident photons in the wavelength range between 340 nm and 1026 nm, with a step size of 0.36 nm. The data measured by the spectrometer can be recorded and processed using the Oventure program running on a computer connected to it.

The examination was performed under artificial lighting. First, the spectrum of the light source (standard 40 W bulb, 350 lm, 2700 K, E27) providing the illumination was determined, and after then the spectra reflected from the solar cell at different elevation angles were measured. The intensity of the reflected light also was determined by calculation, help with the wavelengths and numbers of photons arriving at the sensor.

The reflective effect of the solar cell surface was also compared with the reflectivity of the water surface under the same illumination conditions.

The similarities in the spectral trends for the examined solar cell support the assumption that insect populations that are sensitive to the spectrum, intensity, and polarization of light and use this information for orientation may be misled by the reflectance similarity of the solar cell and the water surface.

The results are accordance with the results of regarding with the light polarizing effect of solar panels results of Takács et al. (2024).

The research draws attention to the fact that this ecological aspect worth considering also taking into account during developing different types of coatings, e.g. selective, self-cleaning, anti-reflective, or combining those for their complex effects.

Acknowledgements

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TESTING THE NITRATE CONTENT OF FRUIT AND VEGETABLES AVAILABLE IN DIFFERENT SHOPS

X. Wang[1], B. Batbold[2], D. Zhengqi[2], Cs. Mészáros[3], Á. Bálint[2]

[1]Doctoral School of Environmental Sciences, [3]Institute of Mathematics and Basic Science,
Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
E-mail: victorwxch@gmail.com
[2]Institute of Environmental Engineering and Natural Sciences,
Óbuda University
Doberdó u. 6., Budapest, H-1034 Hungary
E-mail: balint.agnes@uni-obuda.hu

Good quality agricultural products are essential for human health and the healthy development of children. However, due to the overuse of fertilisers and pesticides, buying or growing good quality food is increasingly rare. One indicator of the quality of fruit and vegetables is their nitrate content. Nitrates are naturally occurring chemical compounds in various foods. The unreasonable use of fertilisers leads to the accumulation of nitrates in plants. Consuming vegetables and fruits with high nitrate content causes serious health problems for consumers.

Scientists in different countries are concerned about the high levels of nitrate in vegetables, fruits, meat and dairy products. The standards for nitrate in food also vary from country to country. In the European Union, for example, the average nitrate content of vegetable products is regulated by Regulation (EU) No 1258/2011. In this study, it was decided to examine and evaluate the different nitrate content of various fruits and vegetables that are considered part of a healthy diet. Are these fruits and vegetables that we buy in different shops healthy? At least, that is what we were looking for regarding their nitrate content.

There are two main ways to test nitrate content: testing the randomly collected dried samples or working with fresh ones. The fruits and vegetables were collected from the following shops: Tesco, Interspar, Spar, Lidl, Prima, Aldi, and Local Market. The collected samples were Beetroot, Orange, Zucchini, Ginger, Redish, White Redish and Apple. Two preparation methods have been used, one for dry form and the other for fresh samples. Fruit and vegetables are chopped using a vegetable chopper. The samples were dried in an oven at 80 ^{o}C for 3 days. Dried fruits and vegetables were pulverised in a mortar. A 0.25 g sample was measured. Nitrate extraction from the powder was the next: add 50 mL of citric acid solution (concentration was 0.2 g/L) to the powder sample and treat it in an ultrasonic bath for 10 minutes. The sample was then filtered twice. Then, 5 mL of the sample was measured into a volumetric flask, and 1 mL of 1 M HCl (to keep the solution in UV light) was added and made up on the signal. Then, fill the flask to the mark with distilled water and homogenise the solution. A similar procedure was followed for fresh fruit and vegetable samples. The nitrate content was determined spectrophotometrically in UV light. In the UV range the samples were measured at both 220 nm and 275 nm. Empirical corrected absorbance formula: $A_{corrected}=A_{220\ nm} - 2*A_{275\ nm}$.

The results showed the following for dry samples: Potato peel has the highest concentration. Fortunately, potatoes are mostly peeled when used for cooking. White radish has the lowest nitrate content, both its peel and pulp. The amount of nitrate in apples and oranges is very similar to that in the skin and flesh of the fruit. These fruits and vegetables had higher nitrate content in the peel than in the pulp. The nitrate content of fruits and vegetables in Interspar and Spar is very different. Radish, both the peel and the pulp, had the highest nitrate content in Spar. There were also significant differences in nitrate levels between apples and oranges. Carrots had the lowest nitrate concentration. The nitrate-N concentration in Tesco resembles Spar's. White radish had the highest nitrate content among the fruits and vegetables, and the peel had a lower concentration than the white radish pulp. The potato has the lowest nitrate content of all. The carrot pulp had a lower nitrate content than the other vegetables and fruits; the same can be seen in the samples from Spar. Potato peel has the highest nitrate-N content. Generally, the local market's fruits and vegetables have the lowest average nitrate content. Excluding radish, the nitrate levels of fruits and vegetables at Interspar were above average for all four. There is a significant difference in the nitrate-N concentration of the apple peel in the four stores. The highest concentration of nitrate-N in apple peel was found at Tesco, while the lowest concentration of nitrate-N was found at Spar. The nitrate-N content of the pulp of carrots is always lower than that of the peel in four stores. Regarding the nitrate content of carrot pulp, Local Market and Spar have low nitrate-N content, while Interspar and Tesco have high nitrate-N content. Like carrots, potatoes have more nitrate-N in the skin than in the pulp. Potato peel has almost similar nitrate-N content in all four stores. However, Interspar potatoes have a much higher nitrate content inside than potatoes from the other three stores. The results show that the nitrate-N content of orange peel was similar in Spar and Interspar. For Interspar, there was no significant difference between the nitrate-N content of the peel and the inner pulp, unlike the values measured in other fruits and vegetables. The pulp of Spar oranges had a higher nitrate-N content than the peel, and a similar conclusion can be drawn for the other three oranges. The nitrate-N content of white radishes varies from store to store. Tesco had the highest nitrate-N content in white radishes in the inner part of the vegetable. The lowest nitrate-N concentration in white radishes was found in Interspar, both in the peel and the pulp. Spar white radish had the highest internal nitrate-N content in the middle of the range. In contrast, the peel of the white radish at Spar had the highest N in the three stores. There is no significant difference between the nitrate-N content of the peel of white radish from Tesco and Interspar. The data suggest that buying Interspar white radishes seems to be a good choice. The nitrate content in fresh samples showed the following results: Beetroot exhibited the lowest nitrate values among the fresh samples from Spar. Notably, the non-peeled zucchini samples exhibited the highest nitrate concentration among the three. Furthermore, ginger and radish samples demonstrated considerably higher nitrate levels. These findings highlight the variations in nitrate content across different types of fruits and vegetables, emphasising the importance of considering individual produce when assessing dietary nitrate intake. In the context of Lidl, all the samples showed an elevated nitrate value compared to those obtained from Spar. Remarkably, all five other samples surpassed the 1000 mg/kg threshold except non-peeled zucchini, indicating substantial nitrate concentrations. Among these samples, radish demonstrated the highest nitrate content, registering a notable value of 1955.46 mg/kg. This observation underscores the significant disparities in nitrate levels across different fruits and vegetables sourced from distinct grocery stores, with Lidl displaying a higher nitrate average of 1336mg/kg. In the case of Prima, the two zucchini samples exhibited the lowest nitrate values, measuring 664.30 mg/kg and 583.71 mg/kg, respectively. However, all the other samples from Prima surpassed the 1000 mg/kg mark, with an average nitrate content of 1,249.49 mg/kg. These findings indicate that while zucchini samples from Prima showed relatively lower nitrate levels than other fruits and vegetables, the remaining produce from Prima demonstrated higher nitrate concentrations. For Aldi samples, it was observed that they had the second-highest total nitrate content compared to the other stores, with Lidl having the highest overall. However, there were notable differences in the specific fruits and vegetables. The orange samples exhibited the highest nitrate content for Aldi, while for Lidl, it was radish.

Nitrate is relatively harmless, but its reaction products as nitrite and N-nitroso compounds can harm health. If nitrate levels in drinking water are below 10 mg/l, vegetables become primary source of nitrate intake. The fruits and vegetables studied by the WHO-recommended diet resulted in little excess nitrate intake. However, white radish from Tesco is high in nitrate.

RADIATION LIMITED YIELD POTENTIAL OF MAIN CROPS UNDER SELECTED APV-DESIGN TYPES – A CASE STUDY FROM SPECIFIC SITE IN AUSTRIA

P. Weihs[1], S.Thaler[1,2], K. Berger[3], J. Eitzinger[1], A. Mahnaz[3], V. Shala-Mayrhofer[4] and S. Zamini[3]

[1]Institute of Meteorology and Climatology, BOKU University, 1180 Vienna, Austria
[2]CzechGlobe – Global Change Research Institute CAS, 603 00 Brno, Czech Republic
[3]AIT Austrian Institute of Technology GmbH, 1210 Vienna, Austria
[4]Austrian Chamber of Agriculture, 1015 Vienna, Austria
E-mail: philipp.weihs@boku.ac.at

Agrivoltaics (APVs) are an emerging technology in Europe that facilitates the dual use of farmland for energy generation and food production. Since photosynthesis depends on photosynthetically active radiation, shading from APV panels reduces the available light for crops. Factors such as module row design, materials used, and field orientation play a critical role in determining the ground-level distribution of radiation.

In this study, we present a novel approach for effectively simulating the shading impacts of various APV configurations. This new method uses fisheye photography editing by redrawing the contours of rows of PV modules (Fig. 1). The processed fisheye images are then analyzed with the software Hemiview CanopyAnalysis Software 2.1 SR5 of the company Delta-T devices (www.delta-t.co.uk), which can determine the daily cycle of global radiation below the PV modules for the 12 months of the year (Fig. 2).

Fig. 1. Example of an edited fisheye photograph showing 3 rows of APV modules

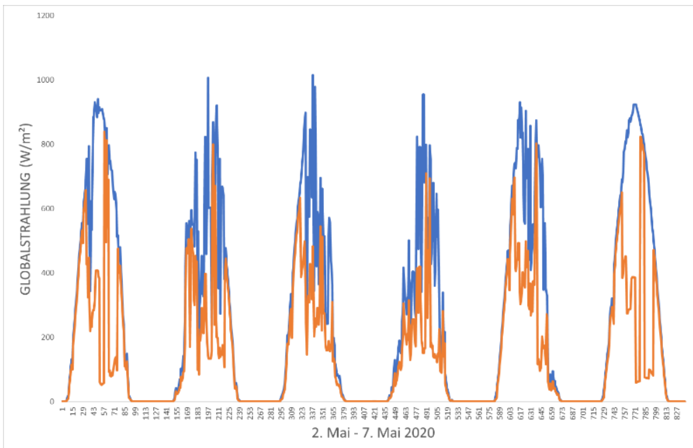

Fig. 2. The calculated data of hourly global radiation below the PV modules (orange line) and above the PV modules (blue line) for the period 2-7 May 2020

A detailed sensitivity analysis was conducted to assess the influence of photovoltaic (PV) system geometry on ground-level radiation and the growth of selected crops. Simulations spanning 2013 to 2021 were carried out for three representative crops in eastern Austria—winter wheat, spring barley, and maize—using seven different APV designs, focusing solely on shading effects. The results indicated that maize and spring barley experienced the most significant reductions in above-ground biomass and grain yield (up to 25%) (Table 1), with marked variations depending on APV design and weather conditions. While spring barley showed consistent yield reductions across years, maize exhibited high variability. Winter wheat, on the other hand, showed smaller reductions, with yields decreasing by up to 10% due to shading and diminished photosynthetic activity. Adverse weather during the growing season – particularly cold, humid, and cloudy conditions – exacerbated yield losses in summer crops like maize, while hot and dry periods had less pronounced effects.

The lowest yield losses across all three crops were observed in an APV design where the modules were oriented eastward, mounted on trackers at a height of 5 meters, and operated with an inclination of +/−50°. This configuration also achieved the highest land equivalent ratios (LERs), with values exceeding 1.06. The proper implementation of trackers in APV systems is crucial to optimizing both agricultural productivity and energy output.

Table 1: Comparison of simulated yield of Maize, Spring barley and Winter wheat with the "open field" yield for 7 different PV designs

Scenario	Maize Yield kg/ha	Barley Yield kg/ha	Wheat Yield kg/ha
0 open field	6188	4076	5680
1	4878	3042	5290
2	5687	3541	5463
3	5105	3176	5199
4	5676	3533	5458
5	5023	3067	5134
6	4956	2999	5025
7	5885	3833	5584

Acknowledgements

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PERFORMANCE ANALYSIS OF SINGLE-PASS SOLAR AIR COLLECTOR USING COMSOL SOFTWARE

QuanKun Zhu[1], I. Farkas[2] and J. Buzás[2]

[1]Doctoral School of Mechanical Engineering, [2]Institute of Technology
Hungarian University of Agriculture and Life Sciences
Páter K. u. 1., Gödöllő, H-2100 Hungary
Tel.: +36 70701636, E-mail: Zhu QuanKun@phd.uni-mate.hu

A single-pass solar air collector is a device that uses solar energy to heat air and serves as the core component of a solar dryer. It typically consists of a transparent cover, an absorber plate, an air channel, an outer casing, and insulation materials. The working principle involves solar radiation passing through the transparent cover to reach the absorber plate. The absorber plate absorbs the solar radiation and converts it into thermal energy, which is then transferred to the flowing air. The heated air is subsequently discharged (Mutar and Alaiwi, 2023).

There are various software tools available for simulation, and COMSOL Multiphysics is one of them. COMSOL offers numerous advantages, such as its capability for multiphysics coupling, high-precision numerical solutions, and support for automatic or manual mesh density adjustment to optimize computational accuracy and efficiency. Additionally, it helps reduce experimental costs and saves time (Abbas et al, 2022).

The aim of this study is to establish a model using COMSOL software for simulation based on experimental data. The experimental results will be used to validate the reliability of the simulation results, providing a foundation for further research. In this study, COMSOL Multiphysics 6.2 was used for simulations. The analysis used was conjugate heat for analysing the heat transfer between the solid and fluid domains, along with laminar regional flow as well as stationary analysis.

The single-pass collector consists of a glass cover, an absorber plate, insulation material and a wooden frame. The configuration of boundary conditions is crucial for the success of the simulation. Referring to the previous study by Yusaidi et al (2024)., the boundary condition equations for the solar air collector are as follows:

Solar radiation through the glass cover regards as the heat flux, it can be expressed as:

$$q_g = I\,\alpha_g \tag{1}$$

where I is solar irradiation, α_g is absorptivity of glass.

The absorber plate has absorber the solar radiation which can be expressed as

$$q_{ap} = I\,\tau_g \alpha_{ap} \tag{2}$$

where τ_g is transmittance of glass cover, α_{ap} is absorptivity of absorber plate.

The heat transfer mechanism through the backplate and insulation material can be expressed as:

$$q_b = U_b(T_b - T_a) \tag{3}$$

where U_b is bottom losses, $T_b$is temperature of backplate, T_a is temperature of air.

The boundary conditions are $x = 0$ (inlet condition) for the heat transfer and laminar flow is expressed as:

$$T = T_{in} \tag{4}$$

Once the boundary conditions are set, the next step is to conduct a mesh independence study. The software offers nine options, ranging from extremely coarse to extremely fine. After comparison, the finer grid option was selected, consisting of 3,597,437 elements with an average quality of 0.6709, as shown in Fig. 1.

After setting the boundary conditions and completing the grid independence analysis, the simulation calculations were performed. The simulation results are shown in Fig. 2. The simulation results were compared with the experimental data to draw relevant conclusions.

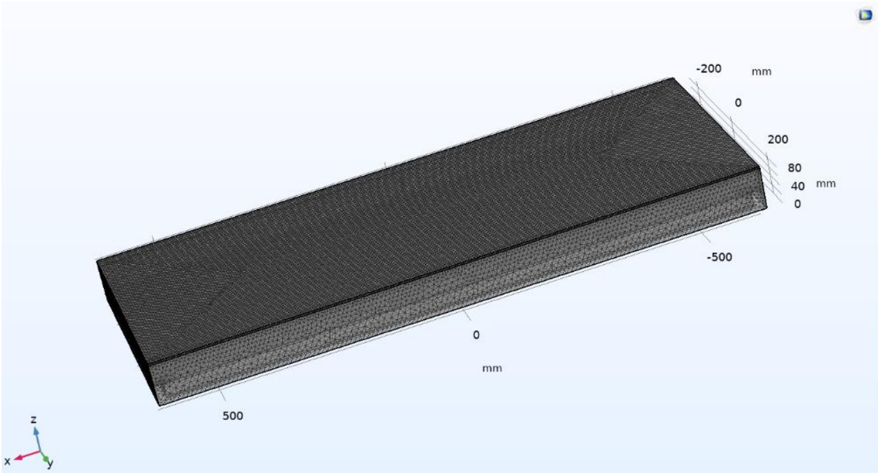

Fig. 1. The mesh independent study

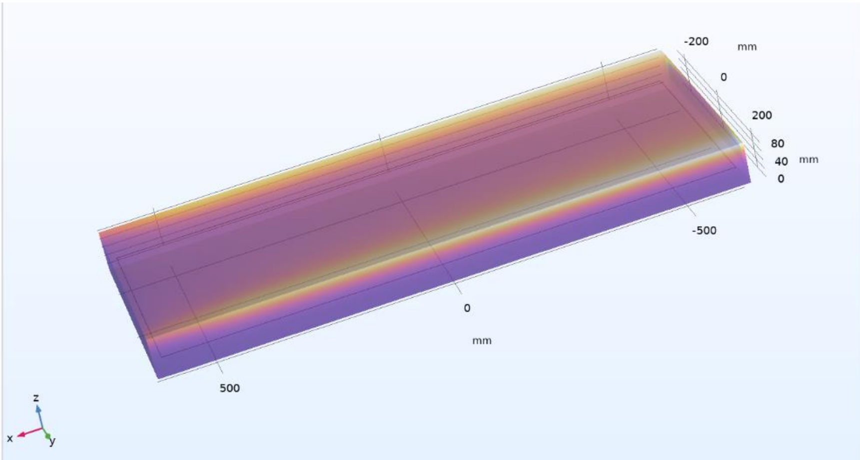

Fig. 2. The simulation result

Acknowledgements

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List of participants

Albayumi, U. A.
Mechanical Engineering Department
Institut Teknologi Nasional
Bandung, Indonesia

Anggraeni, N. D.
Mechanical Engineering Doctoral School
Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary

Antal, N.
Faculty of Environmental Science and Engineering, University Babeș-Bolyai
Cluj –Napoca, Romania

Altaye, A.
Mechanical Engineering Doctoral School
Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary

Ardi, A.S.
Department of Mechanical Engineering,
Institut Teknologi Nasional Bandung,
West Java, Indonesia

Azkiya, Z.M.
Department of Mechanical Engineering,
Institut Teknologi Nasional Bandung,
West Java, Indonesia

Bálint, Á.
Institute of Environmental Eng. and Natural Sciences, Óbuda University, Budapest, Hungary

Bartha, S.
UBB- Cluj – Napoca, Faculty of Environmental Science and Engineering, University Babeș-Bolyai Cluj –Napoca, Extension Sf. Gheorghe, Romania

Batbold, B.
Institute of Environmental Engineering and Natural Sciences, Óbuda University
Budapest, Hungary

Berger, K.
AIT Austrian Institute of Technology GmbH, Vienna
Austria

Bozikova, M.
Slovak University of Agriculture in Nitra
Nitra
Slovakia

Buzás, J.
Institute of Technology
Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary

Carvalheiro, F.
National Laboratory of Energy and Geology
LNEG, Departamento de Biotechnologia, Lisbon, Portugal

Csaba, Zs.
Premontrei Szent Norbert High School
Gödöllő
Hungary

Duarte, L. C.
National Laboratory of Energy and Geology, LNEG, Departamento de Biotechnologia, Lisbon, Portugal

Eitzinger, J.
Institute of Meteorology and Climatology, University of Natural Resources and Life Science, Wien,
Austria

Fadillah, D.M.
Department of Mechanical Engineering,
Institut Teknologi Nasional Bandung,
West Java, Indonesia

Farkas, I.
Institute of Technology
Hungarian University of Agriculture and
Life Sciences , Gödöllő, Hungary

Farros, G.N.
Department of Mechanical Engineering,
Institut Teknologi Nasional Bandung,
West Java, Indonesia

Fauziah, D.
Department of Electrical Engineering
Institut Teknologi Nasional Bandung
West Java, Indonesia

Febrianto, M.A.
Department of Mechanical Engineering,
Institut Teknologi Nasional Bandung,
West Java, Indonesia

Fernando
Department of Mechanical Engineering,
Institut Teknologi Nasional Bandung,
West Java, Indonesia

Fudholi, A.
Solar Energy Research Institute
Universiti Kebangsaan
Malaysia

Géczi, G.
Institute of Environmental Sciences
Hungarian University of Agriculture and
Life Sciences, Gödöllő, Hungary

Gémesi, Z.
Institute of Mathematics and Basic Science
Hungarian University of Agriculture and
Life Sciences, Gödöllő, Hungary

Hadiatna, F.
Departement of Electrical Engineering
Institut Teknologi Nasional Bandung
West Java, Indonesia

Hanif, M.F.
Department of Mechanical Engineering,
Institut Teknologi Nasional Bandung,
West Java, Indonesia

Hartawan, L.
Mechanical Engineering Departement
Institut Teknologi Nasional Bandung
West Java, Indonesia

Hasibuan, T.M.
Department of Mechanical Engineering,
Institut Teknologi Nasional Bandung,
West Java, Indonesia

Horel, A
Premontrei Szent Norbert High School
Gödöllő
Hungary

Iqbal, M.
Mechanical Engineering Departement
Institut Teknologi Nasional Bandung
West Java, Indonesia

Irshad, A.S.
Department of Electrical and Electronics
Engineering, University of the Ryukyus,
Okinawa, Japan

Kátai, L.
Institute of Technology
Hungarian University of Agriculture and
Life Sciences, Gödöllő, Hungary

Kicsiny, R.
Institute of Mathematics and Basic Science
Hungarian University of Agriculture and
Life Sciences, Gödöllő, Hungary

Kidane, H.
Mechanical Engineering Doctoral School
Hungarian University of Agriculture and
Life Sciences, Gödöllő, Hungary

Lidyawati, L.
Department of Electrical Engineering,
Institut Teknologi Nasional Bandung
West Java, Indonesia

Machi, Maytham H.
Mechanical Engineering Doctoral School
Hungarian University of Agriculture and
Life Sciences, Gödöllő, Hungary

Magó, M.
Premontrei Szent Norbert High School
Gödöllő
Hungary

Mahnaz, A.
AIT Austrian Institute of Technology
GmbH, Vienna
Austria

Manopo, D.S.
Department of Mechanical Engineering,
Institut Teknologi Nasional Bandung,
West Java, Indonesia

Mészáros, Cs.
Department of Physics
Hungarian University of Agriculture and
Life Sciences, Gödöllő, Hungary

Mikhaylov, A.
Financial Faculty, Financial University
under the Government of the Russian
Federation, Moscow, Russia

Muluk, M.D.A.
Department of Mechanical Engineering,
Institut Teknologi Nasional Bandung,
West Java, Indonesia

Mutaqin, I.
Department of Mechanical Engineering,
Institut Teknologi Nasional Bandung,
West Java, Indonesia

Negash, T.
Mechanical Engineering Doctoral School
Hungarian University of Agriculture and
Life Sciences, Gödöllő, Hungary

Nikolényi, I.R.
Department of Physics
Hungarian University of Agriculture and
Life Sciences, Gödöllő, Hungary

Nugraha, N.
Mechanical Engineering Departement
Institut Teknologi Nasional Bandung
West Java, Indonesia

Parenrengi, A.M.M.B.
Department of Mechanical Engineering,
Institut Teknologi Nasional Bandung,
West Java, Indonesia

Permana, D.I.
Mechanical Engineering Doctoral School
Hungarian University of Agriculture and
Life Sciences , Gödöllő, Hungary

Pintér, G.
Renewable Energy Research Group
University of Pannonia
Nagykanizsa, Hungary

Putra, M.A.
Department of Mechanical Engineering,
Institut Teknologi Nasional Bandung,
West Java, Indonesia

Radiansah, Y.
Research Center for Energy Conversion and
Conservation, National Research and
Innovation Agency, Bandung, Indonesia

Rajani, A.
Research Center for Energy Conversion and
Conservation, National Research and
Innovation Agency, Bandung, Indonesia

Rátkai, M.
Mechanical Engineering Doctoral School
Hungarian University of Agriculture and
Life Sciences, Gödöllő, Hungary

Rifansyah
Department of Mechanical Engineering,
Institut Teknologi Nasional Bandung,
West Java, Indonesia

Royandi, M.D.
Department of Mechanical Engineering,
Institut Teknologi Nasional Bandung,
West Java, Indonesia

Rusirawan, D.
Department of Mechanical Engineering
Institut Teknologi Nasional (ITENAS)
Bandung, West Java, Indonesia

Sanjaya, K.H.
Research Center for Intelligent Mechatronics, National Research and Innovation Agency, Bandung, Indonesia

Saputra, H.M.
Research Center for Intelligent Mechatronics, National Research and Innovation Agency, Bandung, Indonesia

Seres, I.
Department of Physics
Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary

Shala-Mayrhofer, V.
Austrian Chamber of Agriculture
Vienna
Austria

Subagio, D.G.
Department of Mechanical Engineering, Institut Teknologi Nasional Bandung
West Java, Indonesia

Subekti, R.A.
Research Center for Energy Conversion and Conservation, National Research and Innovation Agency, Bandung, Indonesia

Szabó, I.
Institute of Technology
Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary

Székely, L.
Institute of Mathematics and Basic Science
Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary

Taufik, A.
PT Performa Integritas Indonesia (Fortasindo), Bandung, Indonesia

Thaler, S.
Institute of Meteorology and Climatology, University of Natural Resources and Life Science, Wien, Austria

Touaref, F.
Mechanical Engineering Doctoral School
Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary

Usman, M.
Mechanical Engineering Doctoral School
Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary

Víg, P.
Department of Physics
Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary

Wang, X.
Doctoral School of Environmental Sciences
Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary

Weihs, P.
Institute of Meteorology and Climatology, University of Natural Resources and Life Science, Wien, Austria

Zamini, S.
AIT Austrian Institute of Technology GmbH, Vienna
Austria

Zhengqi, D.
Institute of Environmental Engineering and Natural Sciences, Óbuda University
Budapest, Hungary

Zhu, QuanKun
Mechanical Engineering Doctoral School
Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary

HUNGARIAN UNIVERSITY OF
AGRICULTURE AND LIFE SCIENCES